BRAINWASHING

IMAGINE THAT YOU KNOW something that must be kept secret. Then imagine that you have been captured by people who want to know your secret.

They lock you up; they frighten you. They force you to go hungry; they won't let you sleep. As time passes, you become more and more confused. Eventually, you are so desperate for them to leave you alone that you tell them the secret. The way in which the secret was obtained is called brainwashing.

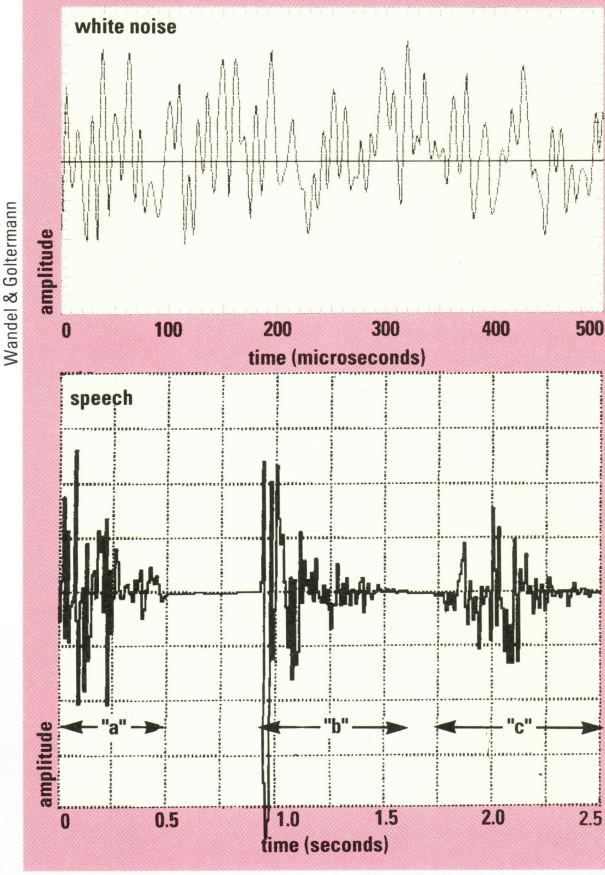
In everyday life, you make sense of the world by comparing your brain's store of knowledge with information gathered by your senses – your ears, eyes and so on. A good example of this is the fluid in your inner ear. This is used to tell the brain whether you are standing up or lying down. If you spin round and round, your brain can't tell what is going on and you feel dizzy. Dizziness is the brain's way of telling you to stop.

In brainwashing, people do the same sort of thing to all your senses. When this happens, your brain can't work properly. The only way it can sort the problems out is to try and stop what is confusing it. If it believes that the confusion will stop if you do certain things, then it will tell you to do those things.

The method that the brainwasher uses to cause this confusion is called 'sensory deprivation'. One way is to use 'white' noise. This is like static on the radio. It constantly changes in volume and in frequency. When white noise is used in a certain way, the mind cannot make sense of what it is hearing.

Visual deprivation – depriving a person of their sense of sight – is

WHITE NOISE – SOUND WITHOUT SHAPE

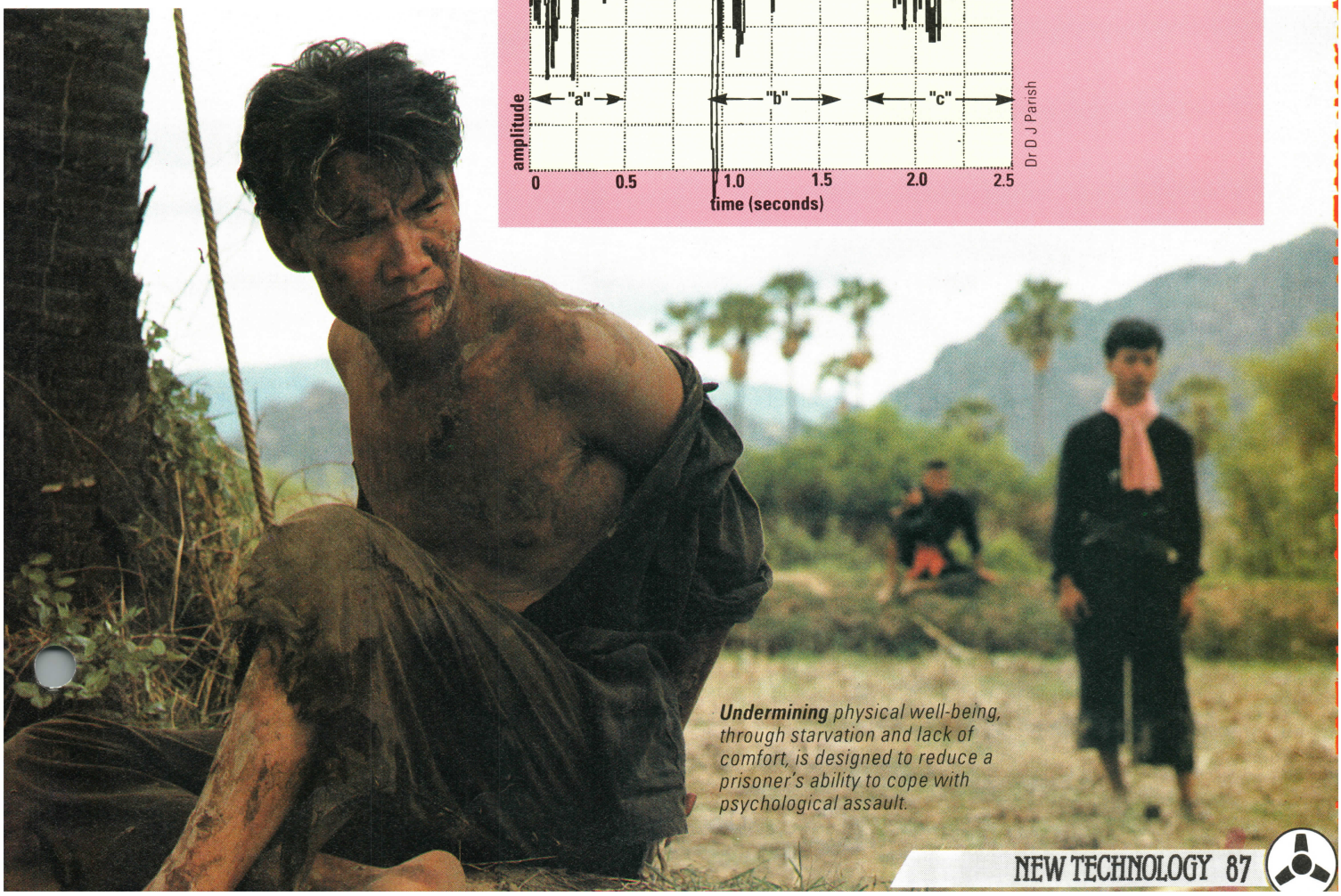


Wandel & Goltermann

Dr D J Parish

The horrible hiss between stations on an FM radio is white noise. Like white light, it consists of a mixture of wavelengths.

The sound of white noise confuses prisoners because they cannot detect any recognizable pattern in it. In speech, however, we can detect differences in how each sound starts, continues and then dies away.



David Appleby/Warner Bros

Undermining *physical well-being, through starvation and lack of comfort, is designed to reduce a prisoner's ability to cope with psychological assault.*

INTERROGATION

A clever interrogator does not need to terrify or brainwash anybody. He or she can usually gain a person's confidence by using various tried and tested interrogation techniques.

First the prisoners are separated. Questioning starts immediately afterwards, before the prisoners have a chance to gather their wits.

This gives the interrogator an initial advantage, which he or she follows up by quoting a few facts that imply the whole conspiracy has been exposed. All that remains is to fill in a few details. Once the process has started, the interrogator is not brutal – simply firm and remorseless, giving the prisoner the feeling that there is no way out.

another technique used to disorient and confuse. The most simple method is known as hooding, and involves covering the prisoner's eyes. A more sophisticated technique is to place the person in a room in which all straight lines have been removed so that it is impossible to tell where the walls, floor and ceiling begin or end.

Sensory deprivation is most effective when all the senses are attacked at once. One way of doing this is to place the prisoner in an enclosed, soundproof tank of warm, salty water. Enclosing the tank produces total darkness so the eyes cannot function. Soundproofing it deprives the ears of any stimulation. Floating the person in water (the high salt content provides bouyancy) destroys the sense of balance. The water is even kept at the same temperature as human blood, so the brain cannot work out where the body ends and the water starts.

Strangely enough a short period of time, say 20 minutes, in a tank under these conditions is very relaxing – so much so that it is sometimes used therapeutically to induce a deep sense of relaxation. However, a long period – 24 hours or more – spent in a flotation tank can reduce a trained soldier to a gibbering wreck.

For brainwashing to be fully effective, sensory deprivation techniques are combined with other, more traditional, methods of ill treatment, such as starvation, fear and lack of sleep. Undermining the body's physical well-being in this crude way reduces the brain's ability to cope with psychological attack.

Humiliation

Lack of food becomes an obsession after a week, so the interrogator can start to control the prisoner by offering small amounts of food as a reward for doing humiliating tasks.

Brainwashers further increase fear and psychological distress by using hallucinogenic drugs such as lysergic acid diethylamide. Known as LSD for short, this chemical acts by magnifying a person's fantasies and fears to huge proportions.

While it is surprisingly easy to brainwash a person, it is also easy to go too far and destroy them mentally, particularly when using chemical methods like LSD. One excess dose has been known to push a victim over the edge into madness and cause permanent brain damage.

Prolonged use of sensory deprivation techniques can result in mental breakdown, from which full recovery can only be made slowly. The brainwasher, therefore, has to be careful not to damage the subject so badly that he or she cannot reveal information or do what the brainwasher wants.

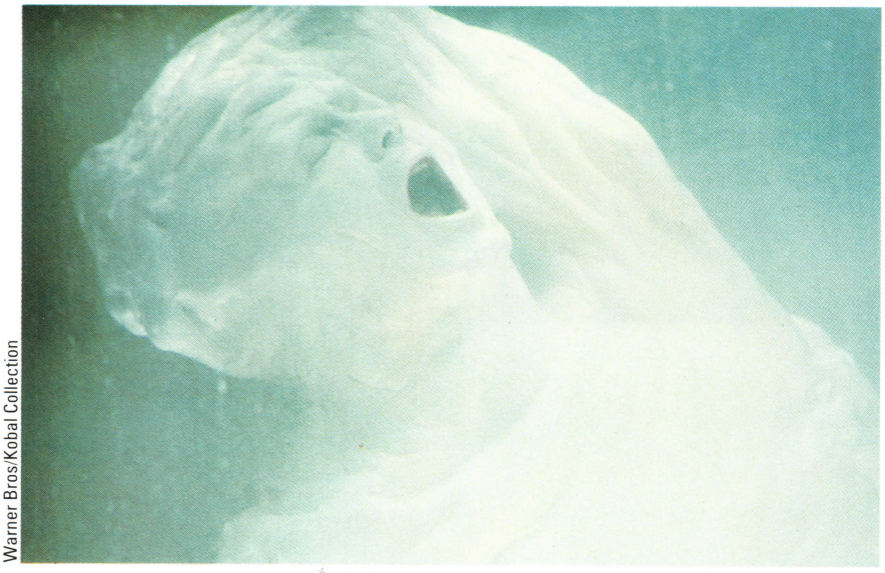
All the types of brainwashing developed so far wear off after a period. If the victim is given reassurance and security, preferably in reassuring conditions and with people that he or she knows well, recovery will soon follow.

Aircrew and members of elite military units, such as the French Foreign Legion or the Russian spetsnaz troops that operate behind the enemy frontline, are all trained to resist brainwashing. Everyday training for this sort of military personnel is fairly tough – but the only way to prepare them for brainwashing is to give them a realistic taste of it. Therefore they are hooded and put in isolation by their own side.

These soldiers are also taught simple techniques, including how to resist friendly advances from the interrogators. The interrogators often work in pairs – the junior acts brutally, while the senior offers some protection and a promise of relief in exhange for collaboration.

So far it has been found that once a man has been broken down physically, such resistance techniques are forgotten and, in the end, all that matters is relief from pain.

Note The techniques described here must not be tried out under any circumstances.



Warner Bros/Kobal Collection

Rex Features

***Loss** of all sense of reality is the result of a prolonged period of sensory deprivation.*

***Cult groups** are alleged to use methods close to brainwashing to make their members conform. Leavers sometimes have to be 'de-programmed' so they can return to normal life.*

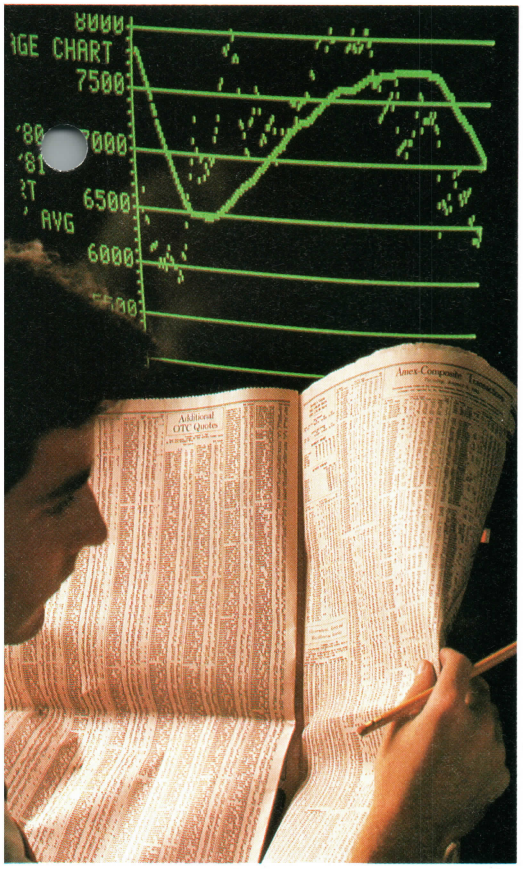
HI-TEC SELLING

MAJOR STOCK EXCHANGES world-wide are now computerized. Stockbrokers work mostly from their own offices, doing deals by phone and computer terminal, instead of meeting on the traditional trading floors of the exchanges to buy and sell shares.

The markets where shares are traded are called stock exchanges. The word 'stock', in this case, meaning government securities and shares in companies whose value can go up and down. If you want to buy or sell shares, you go to a dealer, called a stockbroker, who will do the deal in return for a fee.

Companies issue shares to the public in order to raise the money they need to expand their businesses. People buy shares as an investment. In return, they get paid a part of the company's annual profits, called a dividend. Investors also hope that the value of the shares they buy will increase over the years, so that they can make a profit if they decide to sell them.

If a great many people want to buy shares in a particular company, the price of those shares goes up. But, equally, if many people want to sell, the price goes down.



ZEFA

Image Bank

***The Tokyo Stock Exchange** is a leading world market. Dealers overseas rise early in order to trade there – electronically.*

There are, in fact, two prices for each share: the buy price and the sell price. The market's sell price is always higher than the buy price.

Automatic trading

Stockbrokers buy and sell shares on behalf of investors. They have to deal through market makers, larger stockbrokers who hold quantities of shares for sale and who set the prices.

The key to all this is SEAQ (the Stock Exchange Automated Quotations system) operated by the London Stock Exchange, now called the International Stock Exchange.

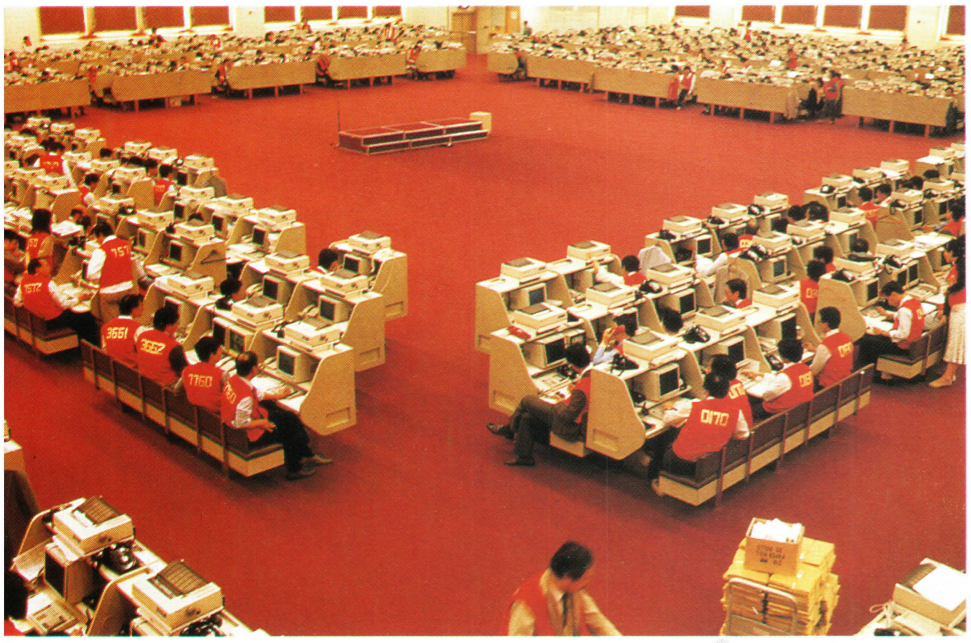
Some 360 stockbroking firms are members of the Exchange which, in a year, handles the buying and selling of shares worth a total of about £1000 billion.

The shares of over 3,500 companies are traded on SEAQ, which has its main computers in the Stock Exchange building. Market makers key their buy and sell prices into the system on terminal keyboards in their own offices.

***The rise** and fall of share prices can now be noted on screens. Computer graphics give an instant (and easier) visual guide than the columns of a newspaper.*

***Wall Street** is the popular name for the New York Stock Exchange, a characteristically bustling market in spite of the computer aided trading.*

Image Bank



ZEFA

Labelled and ranked *like jockeys at their stalls, dealers on the Hong Kong Stock Exchange sit poised in front of their screens to trade in shares.*

In the USA, NASDAQ (National Association of Securities Dealers Automatic Quotation system) is an enormous network of computers and terminals, linking the offices of thousands of share dealers (stockbrokers and market makers) all over the United States and around the world.

The American way

NASDAQ lists the shares prices of about 5,000 American companies. Its terminals are installed in over 6,000 dealers' offices in the USA, and there are over 8,500 terminals installed in other countries.

It is also possible for individual investors to be linked to the system – over 100,000 already are. They pay a subscription and get basic share price information via a small computer terminal.

When SEAQ first came into use in the UK, a broker wanting to buy or sell shares in a company would call up the details on his own terminal. The screen would show him the buy and sell prices offered by all the market makers dealing in those particular shares. Then he would choose the one offering the best price and phone up to make a deal.

This method is still used, but brokers can now also buy or sell automatically, by using one of the new electronic dealing systems.

Time watching *is essential since the world's major stock exchanges are linked to each other by satellite and deals can be made round the clock.*

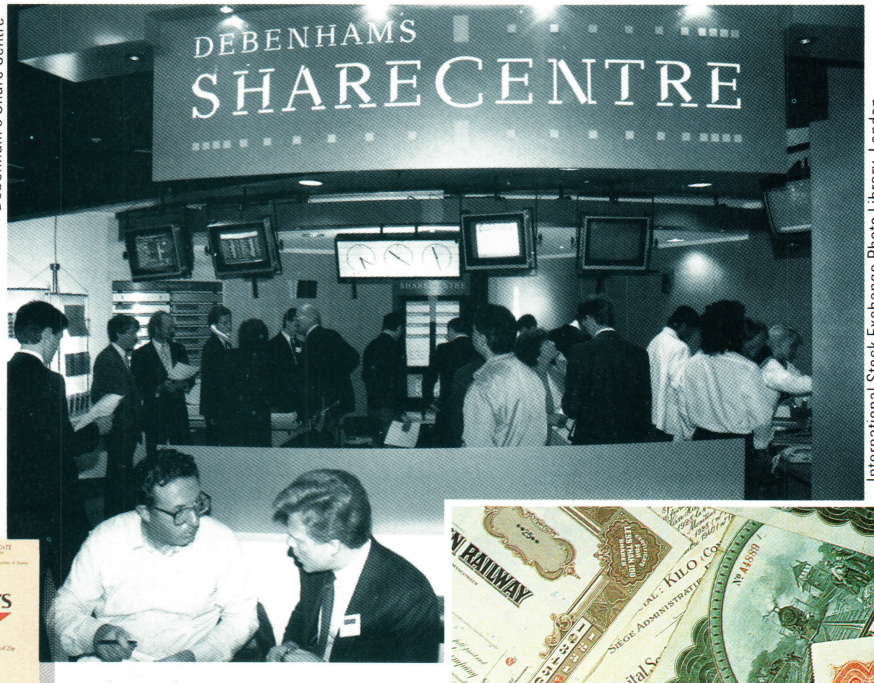
With an electronic dealing system, stockbrokers can simply key in their buy and sell orders on their terminals. The deal is then automatically processed by computer.

Electronic dealing

When using these systems, brokers have to buy from (or sell to) the market maker operating it. But the operator guarantees to match the best prices on offer from the other market makers, so brokers can be sure of making a fair deal for their clients.

Another system called SAEF (SEAQ Automatic Execution Facility) is operated by the Stock Exchange itself. SAEF went 'live' in

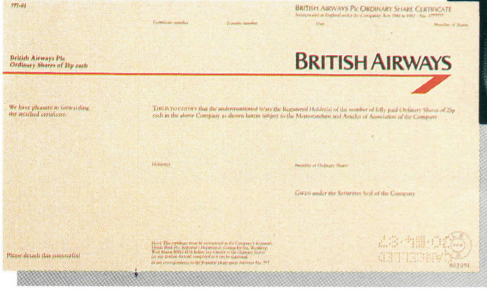
Image Bank



Debenham's Share Centre

International Stock Exchange Photo Library, London

Share shopping *has been made much easier in Britain with the introduction of 'share shops' – independent dealers who can buy and sell shares for anyone who cares to buy during a normal shopping spree.*



International Stock Exchange Photo Library, London

Slim and simple*, today's share certificate is available to a wider public, in contrast to the elaborate bonds (inset right) once issued to an élite.*

International Stock Exchange Photo Library, London

***Hawking shares** on the floor of the International Stock Exchange in London. Stockbrokers can now act as market makers – holding supplies of shares for sale to other brokers – and as agents for investors, simply buying and selling on their behalf. Before the 'Big Bang' in October 1986, only jobbers, distinguished by the top hats they wore, were allowed to make markets in shares on the floor of the exchange.*

***A computerized stock market** means that stockbrokers are kept in instant touch – not only with the changing prices of their own stock market, but also with those of stock markets around the world. Most dealing is now done straight from the dealer's desk by telephone, leaving the exhange's floor a less busy place than before.*

Peter Ryan/Science Photo Library

February 1989 and all the market making companies on the Exchange are linked into it. The only equipment a broker needs is a terminal (any IBM compatible personal computer) with a printer, linked to the system via an integrated data network.

Unlike the other systems, which are offered free to brokers (because the operators get the commission on all the deals made through them), brokers have to pay to use SAEF. They pay a fee of about £2000 to join the system, plus a few pence for each deal they make on it.

When a broker keys a buy or sell order into his SAEF terminal, the central computer finds the market maker offering the best price and makes the deal automatically. There is no need for the broker to check all the different market makers' prices, then phone the one he wants to deal with.

When the SAEF computer has done the deal, it sends a message to the broker's computer telling it what the deal was. The message appears on the computer screen and is also printed out.

Information

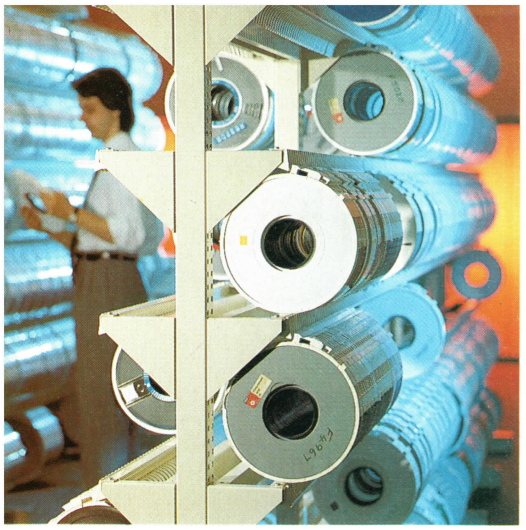
A company's share prices can be affected by all sorts of things, apart from the way its business is performing: politics, wars, strikes, crime, the activities of rival companies and even the weather. So, brokers and market makers need up-to-date news and information to help them make their business decisions.

To meet this need, many electronic information systems have been set up. The information is sent by

MONEY TALKS

In the fast and furious world of trading on the international stock markets, a language of its own has evolved.

Alpha shares: the 100 most actively traded shares on the International Stock Exchange, London.
Arbitrageur: someone who buys shares, commodities or currencies in one market to sell at a profit in another.
Bear: someone who thinks share prices are about to fall.
Bull: someone who thinks share prices are about to rise.
Gilts: short for Gilt Edged Securities issued by the British Government to raise money. They are valued in units of £100, pay a fixed rate of interest annually and can be cashed in after a fixed number of years.
Index: (as in the FT 100 Share Index and the Dow Jones Industrial Average): a calculation based on the changes in the values of a number of selected shares.
Listed company: a company whose shares, listed by the Stock Exchange, can be bought and sold there.
Portfolio: a selection of shares owned by anyone.
Security: a general name for stocks and shares.
Stag: someone who buys newly issued shares in the hope of making a quick profit.
Stock: usually means shares, particularly in the USA. Fixed interest stock (like gilts) pays a fixed rate of interest over a fixed period.



Taped *for future reference. Details of all transactions are stored on computer tapes at the International Stock Exchange, London, for use on the mainframe computers. This means that any illegal dealing can eventually be traced back to unscrupulous dealers.*

International Stock Exchange Photo Library, London

cable to terminals rented to the systems' subscribers. As well as brokers and market makers, subscribers also include banks, insurance companies, newspapers and radio and TV stations.

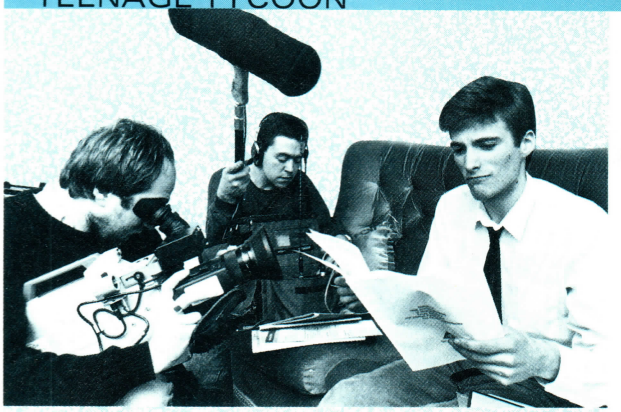
Up to the minute

The International Stock Exchange has a system called TOPIC (Teletext Output Price Information Computer), which carries share price information, Stock Exchange announcements and company news. Other systems include those operated by the financial information service Extel, and by the Reuters news agency, which provides several services.

Reuters Monitor, for example, has over 50,000 terminals worldwide. The Reuter Monitor Capital Markets Service contains 2,500 pages of information, which are regularly updated from over 400 sources.

Reuters also operates a number of interactive systems, which enable subscribers to buy and sell shares electronically. These systems are popular with dealers whose local stockmarkets do not yet provide electronic trading, but they also compete with many existing trading systems.

TEENAGE TYCOON



In November 1987, British schoolboy Christopher Peach, 15 years old, made headlines when he lost £20,000 on the Stock Exchange. He made the deals from a public telephone during school breaks, having managed to raise credit of over £100,000. Unfortunately, when the market crashed in October 1987 so did his portfolio. In 1988, he tried to take over a finance company, but his offer was rejected – because of spelling mistakes.

Ron Duggins

Mainframe *computer banks – the central processing units at the International Stock Exchange – process data fed from tapes according to specific computer programs.*

International Stock Exchange Photo Library, London

Back in the USA

In the USA, Reuters operates a system called Instinet, which lists over 8,000 American shares. Instinet's main rival in the United States is the Telerate system, which has more than 15,000 subscribers. Telerate is owned mainly by the Dow Jones company, who are the publishers of the famous *Wall Street Journal*.

INTO THE FUTURE

MEGABUCKS

Joe Lawrence

▲ *When all the international electronic trading systems are linked via satellite to a single terminal, dealers will be able to operate anywhere – and at any time.*

▲ *To free them from being tied to their terminals 24 hours a day, the computers could be programmed to trade independently within a set limit of prices.*

▲ *Fortunes could be made automatically round the clock – but also lost, if hackers managed to infect the system with mischievous computer viruses.*

SLOT MACHINES

- FAKE COINS
- ELECTRONIC CHECKS
- COMPUTER LINKS

WAR GAMES, HOT FOOD, fortune telling and phone calls are just a few of the things available from slot machines. These machines range from simple, coin-operated units to computerized machines that take coins, banknotes and even credit cards.

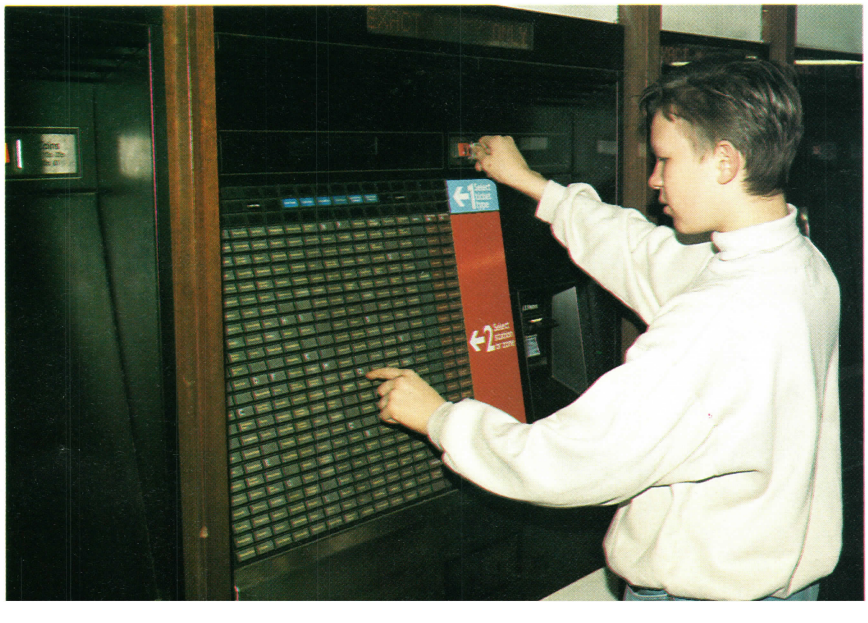
When you use a coin-operated slot machine, it first has to check that you have put in the right money. Each coin goes through several tests, and if it fails any of these it is dropped into the reject chute.

In a small mechanical machine that can take only one type of coin, the slot you put the coin into provides the first test. Any coin that is too big will not go into the slot.

The second test usually involves measuring and weighing the coin. From the slot, the coin drops into a pair of hooked arms on a vertical metal plate, pivoted near its centre. If the coin is too small, it drops straight through the arms and into the reject chute. But a coin of the right size will be caught between the arms. Then its weight will make the metal plate rotate about a quarter of a turn, tipping the coin forwards into the next stage of the mechanism.

A coin that is too light will not

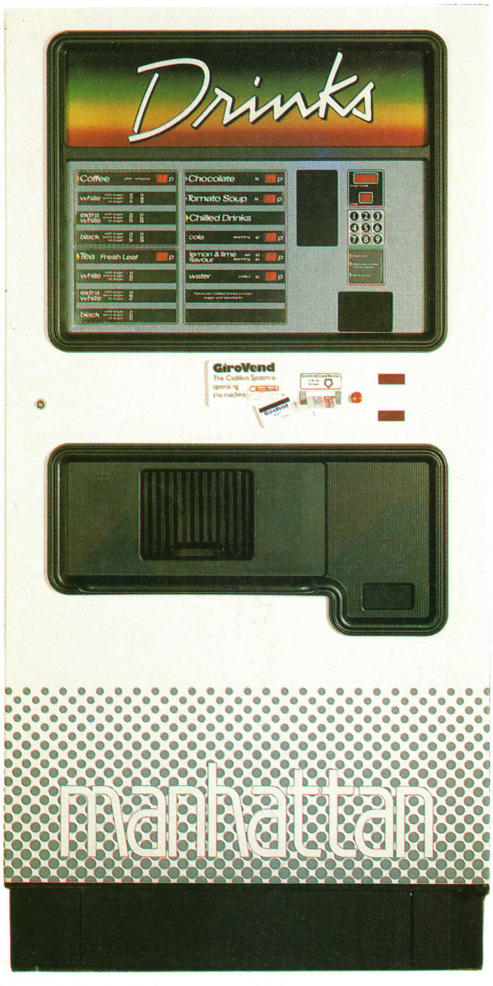
Barnaby's Picture Library



Ray Duns

Many slot machines *attract customers with cash prizes, but the opportunity to control spacecraft and blast aliens is proving addictive too.*

Some ticket machines *have a button for each station. On selecting the type of ticket and your destination, the machine tells you how much to pay.*



***Instead of cash**, this machine accepts payment by plastic card, allowing up to 14 customers to be served in one minute.*

make the plate turn. Instead, the coin will be held between the arms until you press the reject button. This will cause the plate to pivot backwards, dumping the coin into the reject chute.

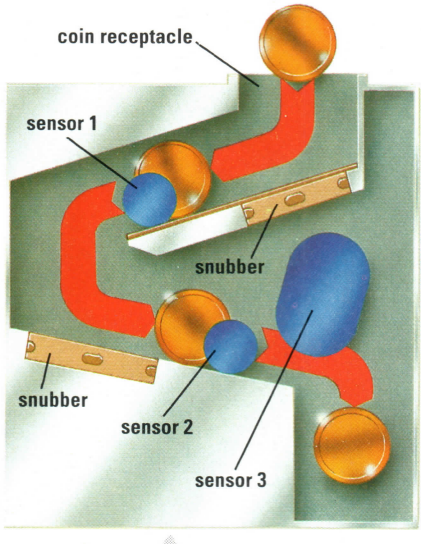
These checks can only tell the machine that the piece of metal it has been checking is of the right size and weight. They cannot tell it whether it is a real coin or not. To find that out, the machine rolls the coin down a slope past a magnet.

When a piece of metal moves through a magnetic field, electric currents called eddy currents are set up in the metal. These currents in turn create their own magnetism – even if the metal is one that cannot normally be magnetized.

As a result, the coin becomes temporarily magnetic when it rolls past the magnet and experiences a force of attraction to the magnet. This causes the coin to slow down as it passes the magnet. The amount by which it is slowed down depends on the strength of its magnetism and this, in turn, depends on what metal it is made of.

Detecting fakes

After passing the magnet, the coin drops off the end of the slope. The angle at which it falls depends on its speed and, if it does not drop at the correct angle, the coin will be rejected. If it does fall at the right angle, the machine will operate and give you what you have selected.



GiroVend

Mark Franklin

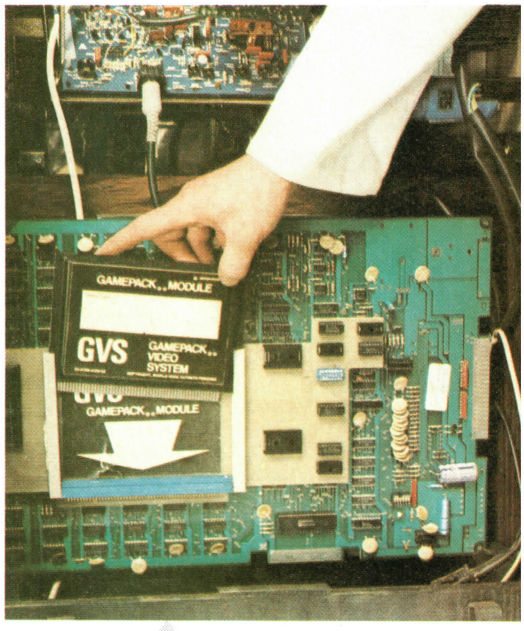
***Signals from sensors** in modern slot machines are used to check coins for thickness (1), material (2) and size and shape (3). Snubbers reduce coin bounce.*

The mechanism is set up so that only genuine coins will pass this test. Fakes, made of the wrong metal, will be slowed down either too much or too little by the magnet. So they will drop at the wrong angle and fall into the reject chute.

Larger machines, especially those that can take a range of coins, add up their values to check how much has been paid and are often designed to give change.

Controlled by chips called microprocessors, these machines use light beams and light-sensitive electronic components to measure the size and thickness of the coins, and to measure their speed as they pass through the magnet section.

Some machines accept notes as well as coins. The notes are fed into a slot, short edge first. The machine shines a light on to the note and, using light sensors, it compares what it 'sees' with the pattern of a good note stored in its memory. If the two match, the machine accepts the note; if they do not the machine rejects the note.



Omni Micro Technology

***Arcade games** machines, like many home computers, can be made to play various games simply by inserting different program cartridges.*

The latest generation of ticket machines, such as those installed in many underground stations, take a wide range of coins and also give change if necessary. Most of these machines are for passengers who know their destination.

To use the machine, you press the button for the ticket you want, then put your money in. Coins of various values can be inserted, in any order, and the machine will give change if necessary. The machine prints the ticket after cutting it from a continuous roll of card and also records details on a magnetic stripe for use in automatic ticket barriers.

Computer networks

In major cities, underground train ticket machines are linked to local computers, and these are linked to a central computer system. Through this computer network, the machines report how much money they have taken and how many tickets they have sold. They also report any faults that might have developed. This information on passenger numbers and maintenance requirements is available to transport controllers at any time, thus helping to ensure a more efficient underground system.

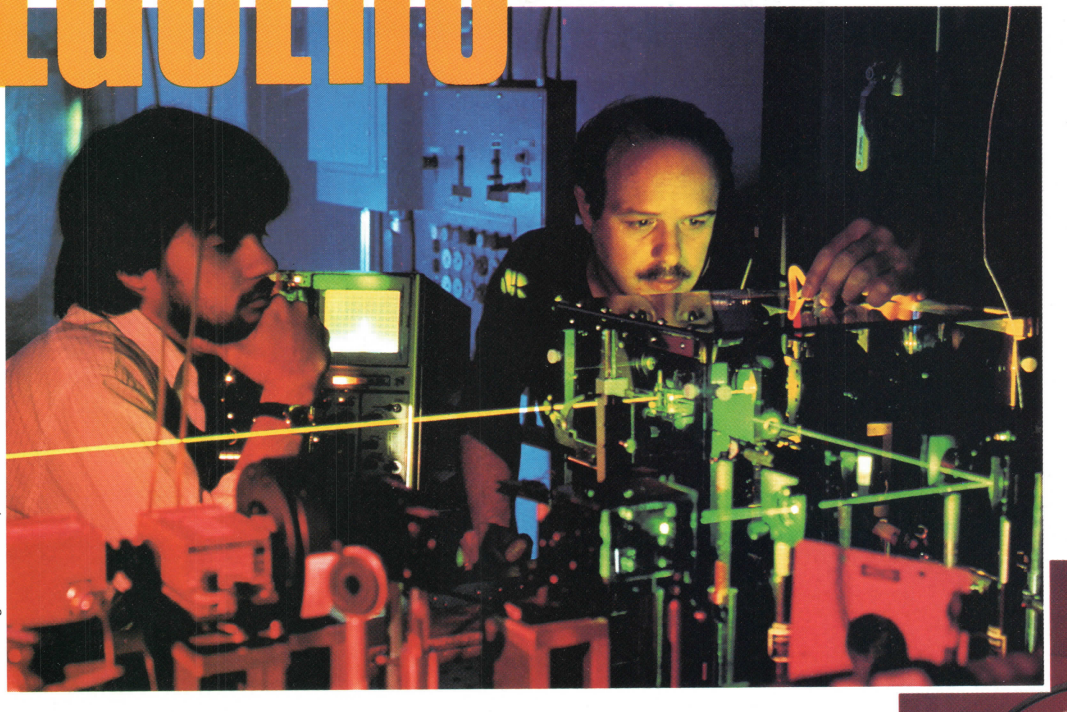
Just amazing!

QUELLE PONG!

VENDING MACHINES THAT DISPENSED SQUIRTS OF PERFUME WERE POPULAR WITH WOMEN IN FASHION-CONSCIOUS PARIS DURING THE 1890S.

Paul Raymonde

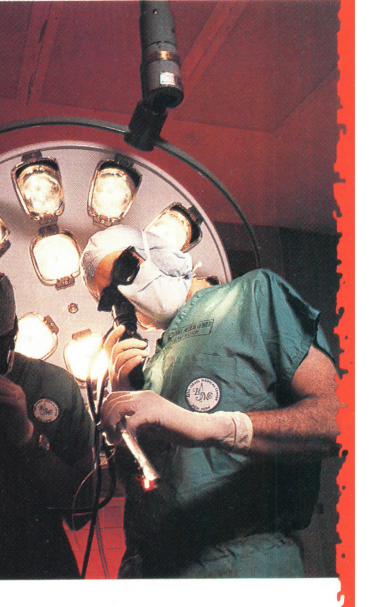
LASERS – HIGH ENERGY LIGHT



Hank Morgan/University of Massachusetts at Amherst/SPL

***Researchers** at work with a laser beam produced by crystals of Yttrium-Aluminium-Garnet, which are sandwiched between plates of the rare metal Neodymium. Y-A-G crystals are also used to make fake diamonds.*

***Endoscopes** – flexible fibre optic tubes – are used to convey laser beams into the body and allow surgeons to work on tissues and organs without having to cut a patient open. TV screens show how the work is progressing.*



Alexander Tsiaras/SPL

- KILLER RAYS
- MEDICAL MIRACLES
- VERSATILE TOOLS

A SURGEON BLASTS AWAY fat clogging the arteries of a heart disease victim, using infra-red laser radiation shone through a tiny fibre-optic tube. Operations such as this could soon be standard practice in hospitals around the world.

Lasers often hit the headlines because of their uses in weaponry, but they have a great many other important applications. They have, for instance, a major role in medicine already.

Since the first one was made, in 1960, lasers have come a long way. In fact, most people have had some dealings with a laser – whether it's the one in a compact disc player, or one used to carry a long distance phone call down an optical fibre, a bar code reader at a supermarket checkout or a light show at a concert. Lasers still have great potential for development and their new applications are continually being discovered.

The name 'laser' is short for Light Amplification by Stimulated Emission of Radiation. The radiation in question may be visible light, or it may be invisible radiation such as infra-red light, ultra-violet light or even X-rays. All these are forms of what is called electromagnetic radiation.

How lasers work

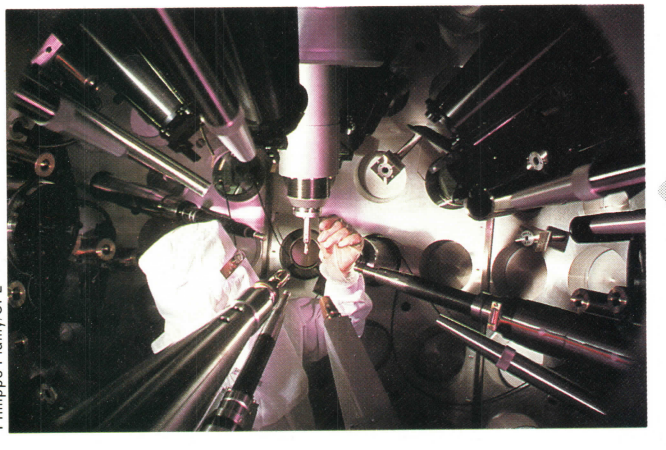
The gas-discharge laser is a good example of how lasers work. A gas, such as carbon dioxide or argon, is contained in a tube with a mirror at each end and has an electric discharge (current) passed through it.

The electric discharge gives energy to the gas atoms and they become what is known as 'excited'. To calm down again, they lose the energy by emitting a photon – a 'particle' of light. This process is the 'stimulated emission of radiation'.

If an excited atom is hit by a photon before it has time to lose its own energy it emits another, identical, photon. If the photon hits a non-excited atom it is absorbed by it, and so is lost.

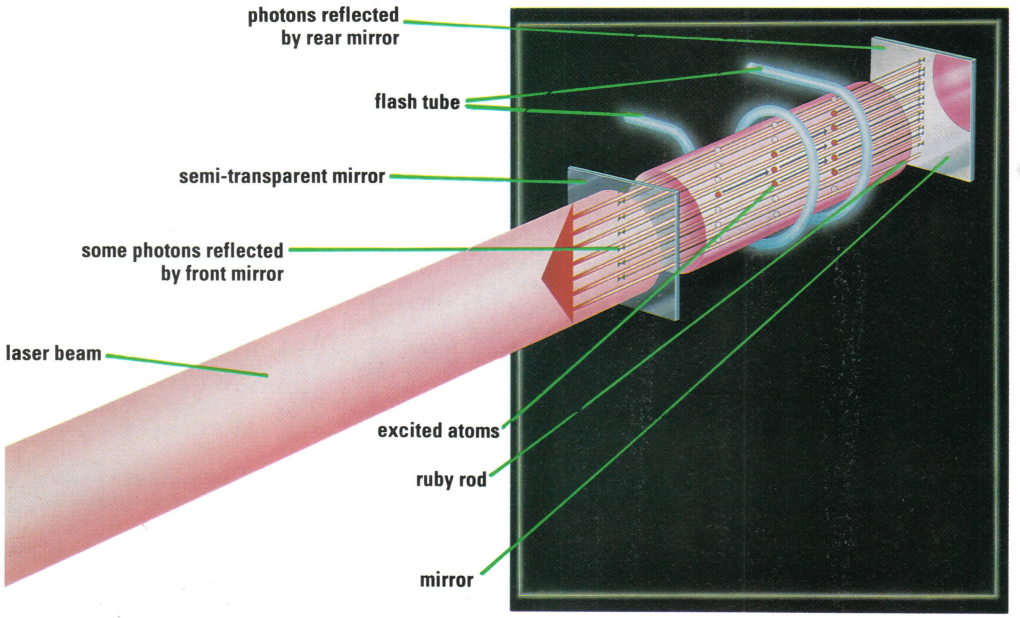
If over half the atoms are excited, the number of photons produced is higher than the number of photons that are absorbed by non-excited atoms. The radiation (light) is thus amplified – this is the 'light amplification' part of the name 'laser'.

The mirrors at each end of the tube reflect the photons backwards



Philippe Plailly/SPL

***Nuclear fusion** is achieved by heating and pressurizing hydrogen isotopes. The Phebus system uses up to 24 separate lasers, which are focused on a frozen pellet of hydrogen in a chamber. For a fraction of a second, this produces conditions like the interior of the Sun.*



A rod of ruby *– better known as a jewel – is often used to make crystal lasers. Light is fed in from the discharge tube, which creates an intense series of flashes. These raise the atoms of the crystal into an 'excited' state, so it gives off photons that buzz back and forth between the two mirrors, until they escape in a narrow, intense beam.*

A 'rainbow tunnel' *is one of the big attractions at the Epcot Center, part of Disneyworld at Orlando in Florida. Lasers fire down fibre optic tubes, which arch over to form a multi-coloured walkway to guide visitors into the world of the future.*

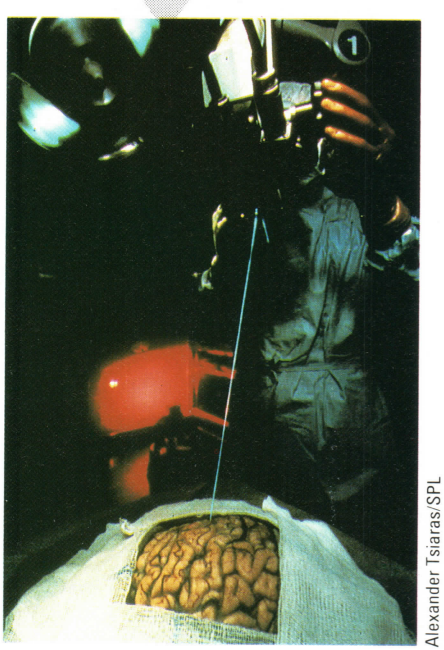
and forwards within it, creating a parallel beam of photons. Keeping the photons bottled up within the tube like this increases the number of them available to create even more photons.

However, one of the mirrors is only partly reflecting. This allows some of the photons to escape, forming a parallel beam of single-frequency laser light. The fact that the light is all of the same frequency is one of the special features of a laser. (Ordinary light is usually a mixture of different frequencies.)

The frequency of a laser's light (and thus its colour) depends on what material is used to produce it. The frequency can range from very high frequency (short wavelength) radiation such as X-ray and ultra-violet radiation, through visible light, to low frequency, long wavelength infra-red (heat) radiation. A typical infra-red laser is one using carbon dioxide gas.

ZEFA

Argon lasers *are used to vaporize brain tumours, cut out damaged sections of brain and anaesthetize pain centres. The heat minimizes bleeding and scarring.*



Alexander Tsiaras/SPL

Another special quality is that the laser radiation is all in phase – all the waves are travelling in step. This is different to the waves of ordinary radiation (visible light, for instance), which are out of step with each other.

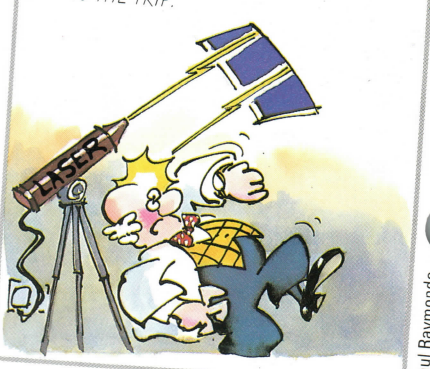
Because it is all in phase, laser light is called coherent light, and its coherence makes it highly valuable as an accurate and powerful tool. For instance, coherent light forms tight beams that don't fan out. This means that the power is concentrated in a small area. Unlike the light from an ordinary 60 watt light bulb, which won't do you much harm, a 60 watt laser beam could quickly burn a hole through you.

There are many types of laser,

Just amazing!

TIMED TO PERFECTION

MEASUREMENTS OF THE EARTH'S DIAMETER ACCURATE TO 20MM ARE MADE BY BOUNCING A LASER OFF A SATELLITE AND TIMING THE TRIP.



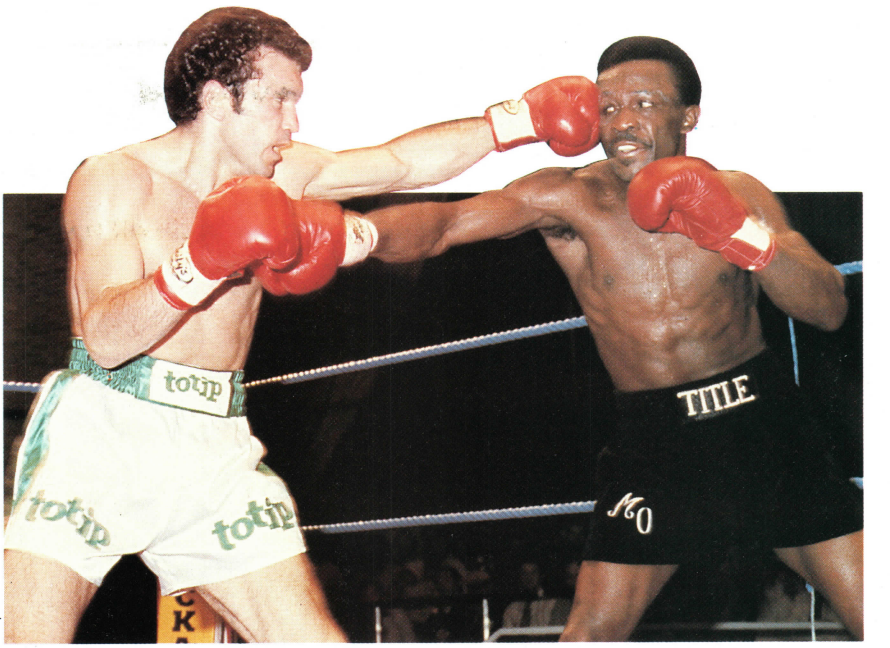
Paul Raymonde

including solid state lasers, gas-discharge lasers, pulsed gas lasers, semiconductor lasers, chemical lasers and dye lasers. They range in power from a few thousandths of a watt or less, to many millions of watts, and deliver their power in either a continuous beam or in pulses.

The huge number of uses for lasers include welding, cutting, drilling, engraving, sending digital signals down optical fibres, the production of holograms, playing compact discs, printing and creating head-up displays in cars and aircraft. They are also used as the basis for many surveying and engineering instruments.

Medical lasers

Many of the most interesting uses of lasers, though, are in medicine. In hospitals, lasers are increasingly being used in place of more traditional surgical implements such as scalpels and knives. They never get blunt, they don't need to be sterilized and the heat they produce seals the cuts they make and so reduces bleeding.



Allsport

Maurice Hope *(right) kept his World title after the retina in his eye was 'welded' back into place using a surgical laser.*

Department of Defense; US Air Force

The AGM-65B *Maverick air-to-ground missile is guided by a laser beam fired at the target by the launch aircraft.*

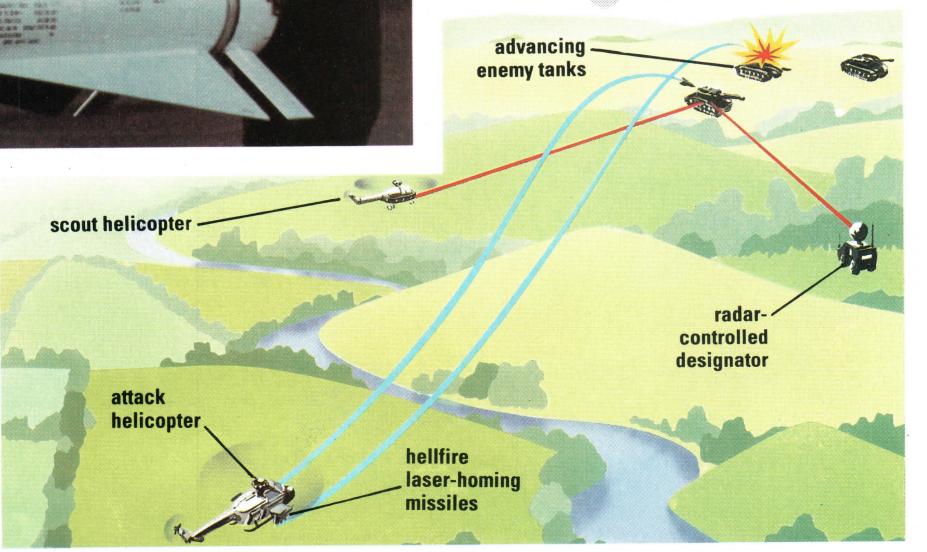
They are also used for operations on places within the body where ordinary surgical tools would not have been able to reach. In addition, because of the nature of the energy they deliver, they can be used for tasks that were previously impossible.

For example, if the light-sensitive retina becomes detached from the rear of a person's eye, it can be welded back into place by a surgeon using an argon gas laser. The beam passes through the eye without harming it and is focused, by the eye's lens, on the retina at the back. There, it makes a tiny spot-weld to fix the retina back in place.

Lasers are also effective at removing skin blemishes, including warts, 'port wine' birthmarks and unwanted tattoos. The energy delivered by a laser is very controllable and skin can be removed in wafer-thin layers. Some laser beams are harmless to ordinary skin and will be absorbed only by skin that is discoloured. A red skin mark, for example, will absorb the energy from a green laser beam while the surrounding skin remains unaffected.

New cancer treatments being developed include photochemotherapy.

Small scout helicopters *cannot carry enough punch to knock out tanks fitted with carbon fibre armour. One solution is to use a laser-equipped scout helicopter to designate the target, which is then attacked with precision-guided missiles launched by heavy attack helicopters operating behind the forward edge of battle.*



Chris Lyon

LASER-POWERED TRAVEL

Interstellar travel requires very high speed to keep journeys within the lifetime of human beings. So plans are being made to send a laser-powered spaceship to Epsilon Eridani, 10.8 light years away.

A group of lasers back on Earth will be focused by a massive Fresnel lens. The beam will then shine through space on to a circular three-stage sail 1,000 km across and blow the spaceship along. It will weigh 75,000 tonnes and accelerate to half the speed of light, giving a journey time of 20 years.

In this treatment, a patient with a cancer is injected with a drug that makes the cancer cells sensitive to light of a certain wavelength. Shining laser light of that wavelength on the cancer will destroy it.

The laser for photochemotherapy is shone down a fibre-optic tube. Incorporated in an endoscope (a thin, steerable tube that can be fed through openings into the body), an optical fibre with a laser shining in one end of it can deliver laser power to many internal parts of the body. Lasers are used in this way for many kinds of treatment, such as to stop stomach ulcers bleeding and to blast away pre-cancerous cells on the neck of the womb.

The light brigade

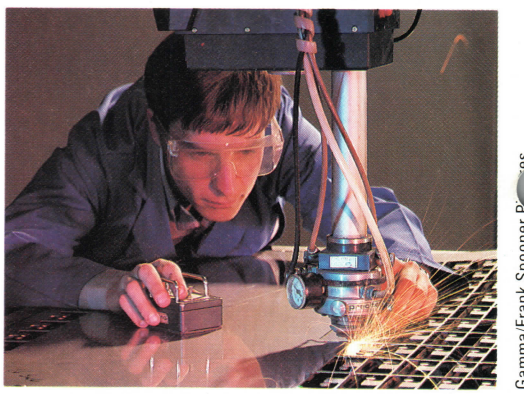
Designers are trying very hard to make lasers into effective weapons of destruction, in addition to their existing military uses in guidance and information systems. For example, laser-guided bombs have far greater accuracy than visually-targeted bombs, while missiles guided by scattered laser light can home in with deadly precision.

Other weapons are used to blind or dazzle infantry or tank personnel with a brilliant flash of light, and lasers are also used as sights for weapons and in military exercises to 'shoot' opponents. But lasers used to destroy targets require vast amounts of energy to power them.

The only power source large enough for this purpose is an atomic bomb. The idea is that a small bomb will be exploded underground and the energy focussed into a large discharge tube.

Gamma/Frank Spooner Pictures

Jean-Michel Jarre's sound *and light show has spectacular giant lasers linked into the sound system so that the lights dance in time.*

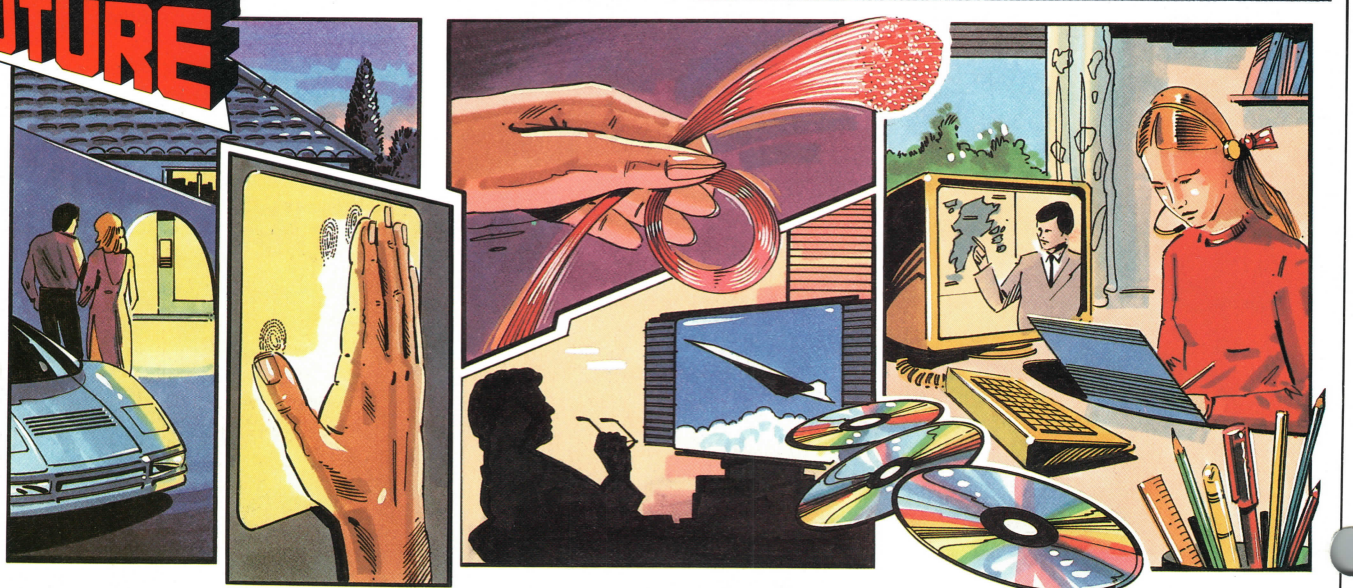


Gamma/Frank Spooner Pictures

Lasers *can deliver a narrow beam of heat energy powerful enough to cut right through metal. When used in metal workshops for cutting out complex shapes, the laser head is mounted on a machine tool called a profile cutter. The cutting beam is controlled by either a human operator or a computer.*

INTO THE FUTURE

LASING AROUND AT HOME



Joe Lawrence

▲ *No need to fumble for keys in the future. To open the front door, members of the family will pass their right hand over the scanning head of a laser.*

▲ *Newspapers will be transmitted direct to the home on a fibre optics cable and be printed out on the laser printer that serves all home computers.*

▲ *Pupils will often work at home because all the books in the school library and many self-teach courses will be available on laser-read discs.*

THE WIDEST SCREEN ANAMORPHIC LENSES EXTRA WIDE FILM

MOVING PICTURES

Imax Systems Corporation

WHEN THE LIGHTS GO DOWN in the Omnimax cinema, the projection system takes the audience right into the action on the screen.

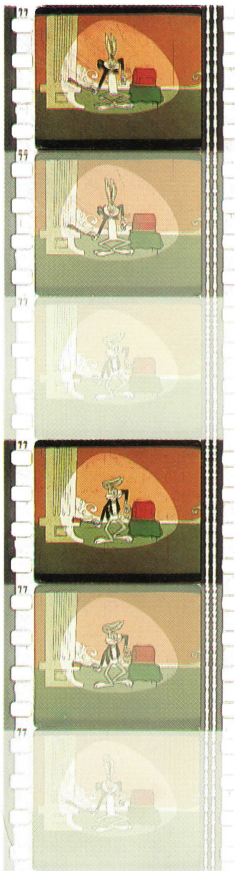
What the cinema actually shows are not, despite their name, moving pictures. A cinema film is simply a sequence of still pictures, basically similar to the ones you take when you're on holiday.

The pictures (or 'frames') are normally taken at the rate of 24 per second, and each one is slightly different from the one before. The pictures only seem blended together because of the speed at which they are shown on the cinema screen.

When we watch a film, our brains interpret the procession of still pictures on the screen as a single, continuously-moving image. If our brains were quick enough to pick out the different pictures on the screen, we couldn't have moving pictures in the cinema or on TV.

***Viewers** sit in reclining seats so that they can take in the whole picture projected on the giant dome-shaped screen of an Omnimax cinema.*

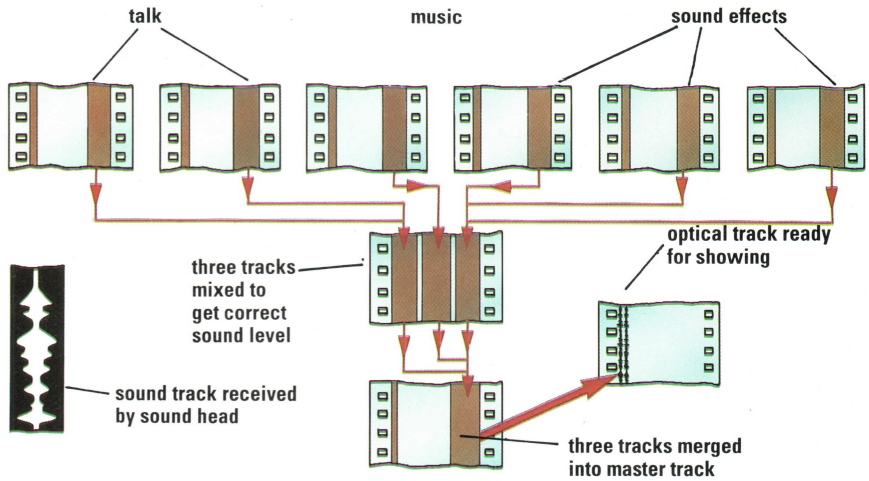
The basic principles behind movie equipment have not changed since movies were invented. In a cine



Warner Bros

Film sound *is made up from six tracks. The first two are the words, the next is the music and the final three sound effects. These are combined in one track and converted to an optical pattern on the finished film. The sound track is 20 frames in front of the pictures, so it can move at a constant speed.*

Bugs Bunny, *shot (like most films) on 35mm film at 24 frames per second. The optical sound track runs down one side, between the edges of the frames and the sprocket holes. As light passes through this, it is picked up by a photo-electric cell that converts the varying light intensity into sound.*



Mark Franklin

camera, a long, continuous strip of film is wound from one reel on to another, passing a shutter and lens.

When the camera is running, the film is stopped for a fraction of a second behind the shutter (which is blocking off the light from the lens). The shutter opens briefly, letting the light from the lens through to expose one image or frame on the film. Then the film moves on and the next frame is exposed.

It's a frame up

The only time that light is allowed to get at the film is during the split second that it is immediately behind the lens and the shutter is open. This normally happens 24 times per second, which is enough to smooth out all but the fastest movements. Higher frame speeds (more frames per second) are used only for special purposes like slow motion and some types of special effect.

The film transport system that carries the film through the cine camera has a series of toothed wheels or sprockets. The teeth on these wheels fit into the sprocket holes up each side of the film.

When all the film on a reel has been exposed, it is removed from the camera and sent away for processing.

The scenes in films are not shot in order. A shooting schedule is drawn up before filming starts, depending on when the stars are available. The day's films are developed overnight and prints are made to check results – these prints are called the 'rushes'.

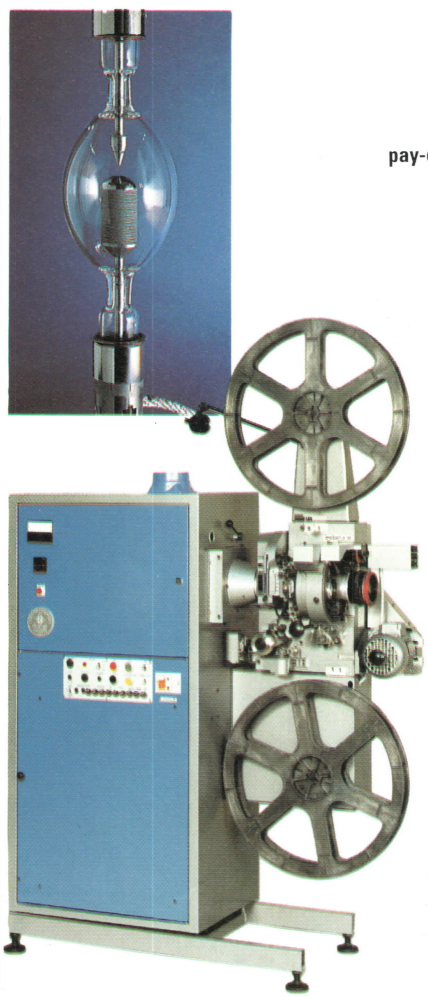
Since standard cine cameras run at a speed of 24 frames a second, the projectors must run at the same speed in order to keep the on-screen action at the proper speed. (The reason many of the old silent movies look jerky and speeded-up is that they were filmed at a slower frame speed than modern projectors run at.)

Film projectors

The beam of light that projects the picture on to the cinema screen is focused by a system of lenses at the front of the projector. For showing, a copy of the processed film is fed into the projector through the 'gate', which guides the film as it passes between the light source – a powerful lamp – and the projector lens.

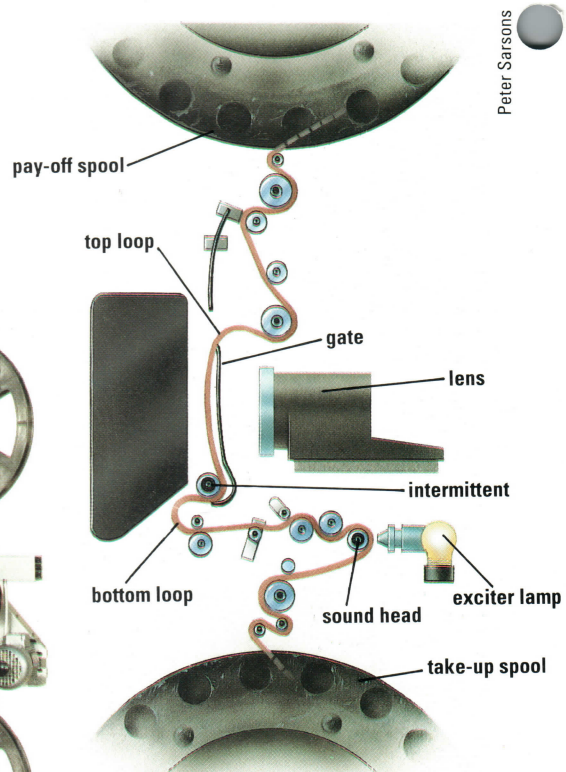
Below the gate is the intermittent, which holds each frame stationary behind the lens for an instant then moves it on. While the film is stationary in the gate, a revolving shutter between the light source and the film opens to let the light shine through the film and project its images on to the screen.

The shutter opens and closes two or three times while each frame of film is being projected. This increases the number of separate images flashed on to the screen



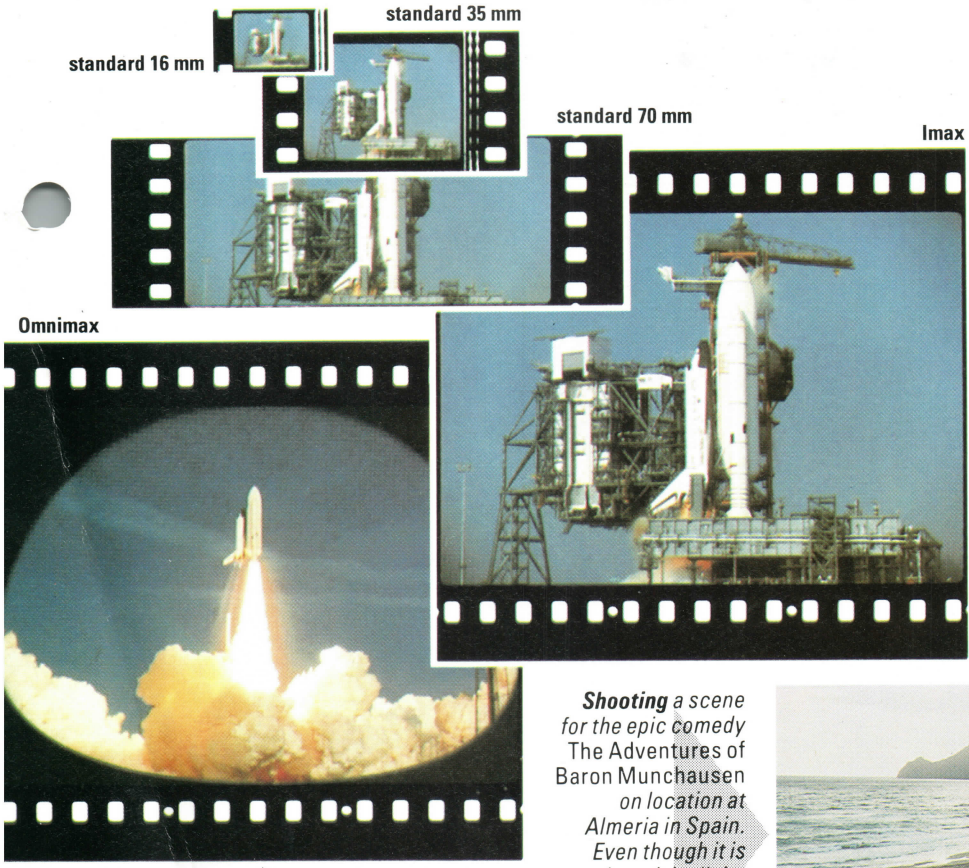
David Bradfield/Sound Associates Ltd

Sound Associates Ltd



Peter Sarsons

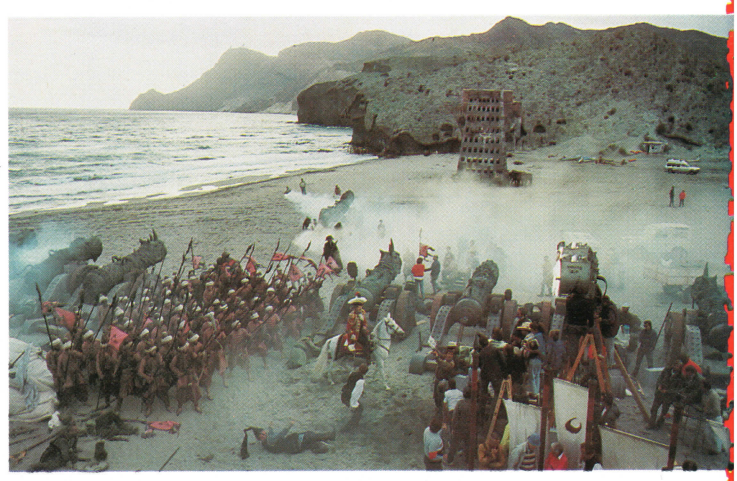
Cinema projectors *are taller than a man. The body of the projector contains the sound equipment, plus the Xenon light source (top left). The film is carried on sprockets, while the intermittent lines each frame up with the lens and pulls it through the projector.*



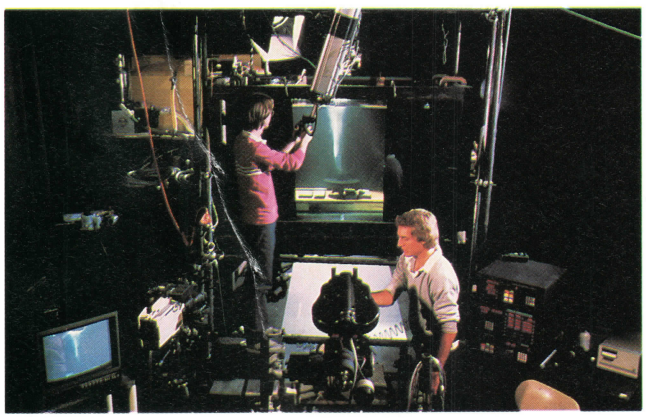
Imax Systems Corporation

Most films *are shot on 35 mm stock: 70 mm is used for big blockbusters as it gives better, brighter pictures. The giant-screen Imax and Omnimax systems use the largest frame and a horizontally moving film.*

***Shooting** a scene for the epic comedy* The Adventures of Baron Munchausen *on location at Almeria in Spain. Even though it is broad daylight, powerful arc lamps are needed to get the scene lit properly.*



Elliott Erwitt/Magnum Photos



MGM/FLM Entertainment

***Special effects** are even more realistic – and more dramatic – these days thanks to new technology, including lasers, digital electronics and computers.*

from 24 to 48 or 72 times a second – well above the flicker rate that the human eye can detect. The shutter closes before the frame moves on, which prevents any blurring of the projected picture.

One unwanted effect of the shutter movement is to cut down the amount of light reaching the screen. To get around this, modern projectors are fitted with powerful Xenon discharge lamps, which are very efficient light sources.

The standard frame size for most films is 35 mm – literally the width of the film – which has also been adopted for many ordinary still cameras. This gives a reasonably bright image over quite a large screen and is fairly cheap to use. But the search for large, high-resolution films has led to many variations in screen size and film format.

Wider and wider

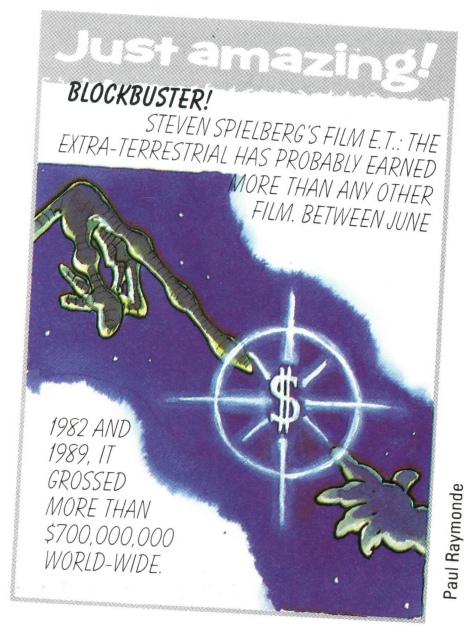
One of these variations was Cinerama, where the enormous size of the cinema screen created the illusion that the viewer was right in the action. The Cinerama screen was so large that three cameras had to take separate films, and three projectors had to be used to project them on to the screen. Unfortunately, the joins between the images tended to show like those in a bad wig.

The best-known Cinerama picture was probably *2001, A Space Odyssey*. This was shot on single lens Cinerama, but has now been transferred to Cinemascope, which needs much less special equipment than Cinerama.

In Cinemascope, a special lens, called an anamorphic lens, is used to squeeze a wide-angle view on to ordinary 35 mm film. When projected at the cinema, another anamorphic lens on the projector spreads the image out again.

Perhaps the best of the wide-screen systems was Todd-AO. This used 70 mm film – twice as wide as standard 35 mm film. In the cinema, Todd-AO produced a wide-screen image twice as wide as it was high. The image was much brighter and could fill the screen better than any 35 mm system could.

Standard 70mm film is still the most popular of all the wide-screen formats and most big-budget films are blown up from 35mm to 70mm for showing. However, only the big, city-centre cinemas have the necessary 70mm projectors to show it. If you get the chance to see a 70mm film, you'll notice that the quality is much better.



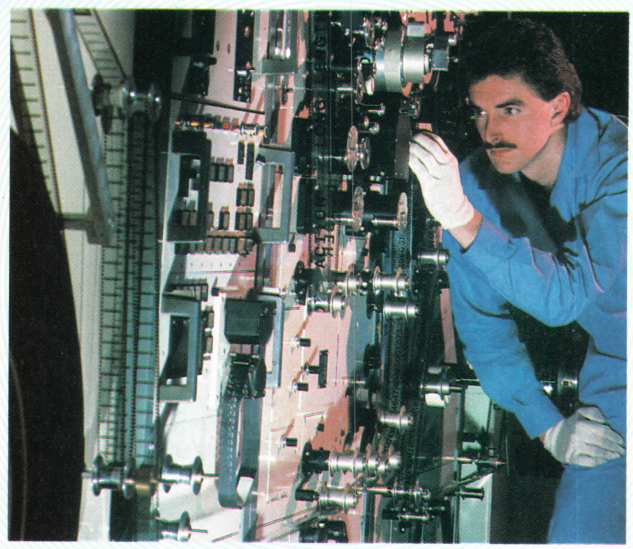
Paul Raymonde

Chris Lyon

An Omnimax theatre *can seat up to 500 people. The audience sit in reclining seats that enable them to look up in comfort at the huge 23 metre screen, which is tilted at an angle of 30 degrees to the horizontal. Omnimax uses 70 mm film, but its image area is a massive 2,665 sq mm – almost two and a half times as big as the 1,072 sq mm image area of the standard-format 70 mm film. Imax theatres hold up to 1,000 seats – and the quality of image in both Imax and Omnimax is unsurpassed.*

Roger Scruggs/Imax Systems Corporation

PRINTS FOR DISTRIBUTION



Rank Film Laboratories

In Imax *and Omnimax cameras, the film moves horizontally instead of vertically. The horizontal reel housings are located to the right of the lens.*

When a movie is shot, the film used in the camera is processed, then a positive is made. This is edited. Then the original negative is edited, the sound is mixed and this version is copied many times to produce the prints that are distributed for showing to the public in cinemas.

An advanced high-definition, giant-screen system is called Imax. Unlike other formats, where the film runs past the shutter from top to bottom, in Imax cameras and projectors the film runs from side to side. Imax cameras use 65 mm film and have the largest frame size ever used in movie cameras. The projectors use special 70 mm copies of it.

The size of each frame is very large compared with any of the other systems, including standard 70 mm. An Imax film therefore allows a lot of light through to the screen, with excellent quality.

A further development of Imax is called Omnimax. In this system, the image is projected through a special fish-eye lens that spreads it out over a screen that forms a half circle. The screen is 23 metres across and set at an angle of 30 degrees to the horizontal. To see the complete Omnimax picture, you have to lie back on a reclining seat so that you can take it all in.

Faster speeds

The other path to higher resolution is by using faster frame speeds. A system called Showscan takes the large 70 mm format used by Todd-AO and runs it past the camera and projector at 60 frames a second instead of 24.

Other experiments are being made, including shooting ordinary 35 mm film at 30 frames a second, to improve picture quality.

Stereo sound

The standard optical sound track is quite wide, so the first stereo pictures had two or four magnetic sound tracks on the side of the film. But adding the magnetic track was difficult and expensive, the magnetic stripe wore as the film passed through the pick-up heads and making prints was a slow process.

So the Dolby Corporation designed an electronic device to take four magnetic tracks and reduce them to two optical ones, the same width as a single optical track. These twin tracks are played back through another Dolby device which decodes the two tracks, producing realistic stereo.

Dolby also produce a noise reduction system. Low-level sounds are boosted during recording and reduced on playback. As a result, the original sounds are reproduced normally, but recording hiss is greatly reduced in the process.

FACTORIES OF THE FOREST

- AXING HARDWOODS
- TAPPING RUBBER
- HYDROELECTRIC POWER

MUCH VALUABLE TIMBER IS found in the rain forests. Woods such as mahogany and greenheart from South America, and teak from South-East Asia have been used by industrialized countries for furniture and building.

These trees are all hardwoods – they have solid, strong, good quality wood with an interesting grain. Because of their grain, many rain forest trees are cut into thin slices and made into veneers.

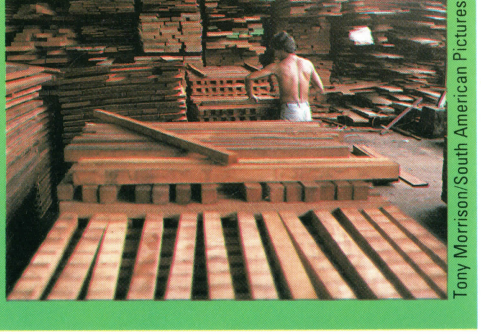
Logging is one of the main causes of the destruction of the rain forests: it devastates 5 million hectares every year. In industrialized countries, demand for hardwoods is growing and countries with rain forests obviously want to sell their wood to make money.

One rain forest tree can bring in up to $1,000 in much needed foreign currency. By the time it has been turned into parquet floors, yacht

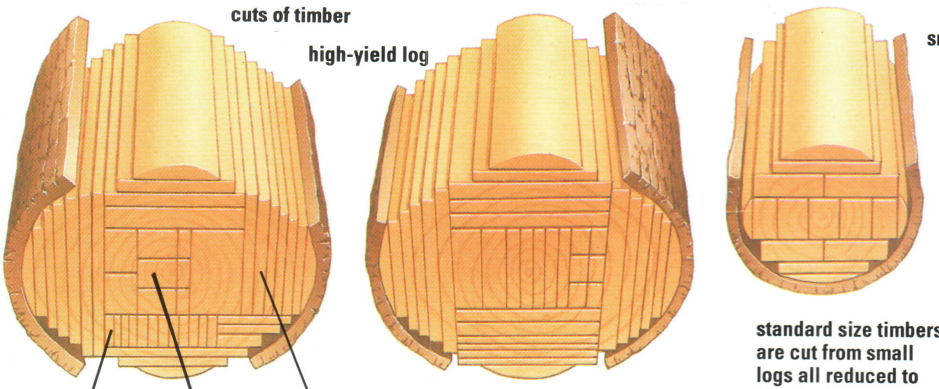
A Venzago/Magnum

The road ahead *for native Indians is a bleak one when highways in rain forests plough right through their homelands and hunting areas.*

Hardwoods*, such as teak, ramin and sapele, are in great demand for furniture because of their attractive close grain. Most of the teak has been cut.*



Tony Morrison/South American Pictures



Chris Lyon

planking and veneers for furniture, its value may have gone up to $17,000.

If industrialized countries used less hardwood, this would bring prices down and would be a major step towards saving the remaining rain forests. In Thailand the total area of tropical forest shrank from 70 per cent to 18 per cent of the country between 1945–89. All logging is now banned in Thailand.

Suitable trees

It has always been difficult to get the valuable timber out of the rain forests. Groups of one species do not grow together, as they do in pine forests, but are scattered throughout the forest. In an area the size of two soccer pitches there may be only three suitable trees. When these trees are chopped down, they damage or destroy the trees around them – rather like a factory chimney crashing across a housing estate.

Dieter and Mary Plage/Survival Anglia Ltd

In one Malaysian forest, although only ten per cent of the trees were cut for timber, more than half were destroyed or severely damaged by bulldozers or rot, which sets in once branches are broken off the trees. When the trees have been cut down, new trees are rarely planted to take their place, as most logging companies are more interested in short-term profits than in planning for future forests.

Apart from the distribution of trees in the forest, other problems for the loggers include the heat, humidity and the abundance of insects. The trees are difficult to fell not only because the wood is hard, but also because many have wide-spreading buttresses, which may be as high as 10 metres above the ground. On a tree like this, loggers may have to build a platform high off the ground in order to reach the straight trunk.

Timber!

After chainsaws have cut down the trees and lopped off the branches, huge cranes, bulldozers and caterpillar tractors move the logs to the collection point. Here, cranes lift the heavy logs on to transporter trucks or lower them into rivers. In a river, the logs are tied together in a raft and towed downstream to a 'log pond', where they are sorted and graded, ready for export.

Despite modern technology, countries such as India and Myanmar (Burma) still find it more economical to use elephants to pull logs out of the rain forests. Elephants can not only move more easily through the forest and do less damage, but one elephant can do the work of four bulldozers.

Vaughan Fleming/Science Photo Library

About three-quarters of the trees felled in rain forests are exported as logs, because few developing countries have the sawmills necessary to deal with more than a small fraction of their annual log harvest.

Processed logs

The developing countries would get at least five times as much money from each tree if they 'processed' the logs (into veneers, for example) before export.

For most countries, the income from exporting mainly unprocessed wood is eaten up by the need to import sawn timber, plywood and paper. Nigeria was once a major timber exporter. It is now on the verge of losing all its forests and

Boards *are sawn from one side of the log at a time. When all four sides have been 'worked', beams are cut from the centre.*

One minute *is all it takes for a machine to reduce a giant tree to woodchips, which are used to make particle and chip board.*

Elephants *are preferred to bulldozers to clear the jungle in many countries. They are more easily available and one animal can do the work of four machines.*

Mangrove swamps *along the estuaries of the Amazon have adapted to the salt content of the water. They provide valuable firewood.*

L C Marigo/Bruce Coleman Ltd

A.J Deane/Bruce Coleman Ltd

***Latex** – a natural resource – is tapped by scoring the bark of a rubber tree. The milky sap collects in a cup.*

imports more than 100 times as much wood as it exports.

Rubber is made from a milky sap called latex, which is produced by certain tropical trees. Rubber was originally harvested from wild trees in the Brazilian jungles. After a while, however, the wild trees were over-tapped and rubber production fell.

Sap-tapping

Spreading industrialization greatly increased the worldwide demand for raw rubber. In 1876, Henry Wickham smuggled 70,000 seeds of the most promising latex producing tree out of Brazil to England – but only four per cent grew. The seedlings were sent to Sri Lanka and Malaysia to start the rubber industry there. There are now an estimated three billion rubber trees in South-East Asia. Malaysia produces nearly half the world's rubber – exports earned nearly $4.5 billion in 1979.

Rubber trees from six to 30 years old are 'tapped' for the milky sap. The latex comes from a layer of tiny tubes spiralling up the tree just underneath the outer bark. Latex contains about 30 per cent rubber by weight. To tap the latex, a sliver of bark is cut at an angle of about 30° to the horizontal so as to cut through many latex tubes.

A cup is fixed to the tree at the bottom of the cut, to collect the latex as it oozes out. After two or three hours, the flow stops and the latex is ready for collection. The next time the tree is tapped, a cut is made just below the first one and so on down the tree. The bark gradually heals and the tree can be tapped again and again.

A more modern technique uses several small holes instead of one large cut. With this method, the bark has to be treated chemically to make sure enough latex flows out of the cut. Chemicals can also be painted on the trunk of the rubber tree to increase yield.

Formerly, the latex was converted to rubber sheets, which were exported in bales weighing over 100 kg each. A more modern method, which is faster and more economical, is to turn the latex into granules. It is chopped, minced or mixed with a crumbling agent (such as castor oil), then passed between rollers to break it up into small pieces.

The granules can be washed and dried in just a few hours. The dried rubber is shaped into bales, weighing 33 kg, these are wrapped in polythene before being shipped to the makers of rubber products.

The energy potential of the rivers in the rain forests is gigantic. Brazil pays over $12 million each day to import oil, so it has every reason to develop its own hydroelectric energy.

The first rain forest dam was completed in Surinam (just north of Brazil) in 1964. Around 150,000 hectares of rain forest were flooded to create a huge reservoir, but as the trees decomposed they produced stinking fumes of hydrogen sulphide gas. For two years, workers at the dam had to wear gas masks.

Tony Morrison/South American Pictures

Dr Morley Read/Science Photo Library

***Excavators** clear the way for road building in the Amazon. The 759 km road (inset right) that links Manaus in Brazil to Boa Vista in Venezuela is only partially paved.*

Cooling problem

The jungle vegetation also made the water acidic and this corroded the dam's expensive cooling system. A similar problem at the Curua Una Dam in the Amazon involved replacing the steel casings of both turbines at a cost of over $5 million.

At Jupai, a dam on the Parana river just outside the Amazon re-

Just amazing!

FILL HER UP

THE SAP FROM THE COPAIBA TREE IN THE AMAZON CAN BE USED TO POWER A DIESEL TRUCK. IT IS ALMOST IDENTICAL TO DIESEL FUEL – IN AN EMERGENCY, IT CAN BE POURED INTO THE FUEL TANK.

Paul Raymonde

gion, the sheer weight of the mass of weeds (such as water hyacinths) growing on the surface of the lake has snapped steel cables.

Jungle highways

Another major effect of building dams, reservoirs and roads through the jungle has been to uproot the Indians who lived there. Indian lands have been used for logging and mining and settlers have moved in to farm the land. In the 1500s, up to nine million Indians lived in the Amazon rain forests. By the 1990's, less than 200,000 Indians survive.

In the 1960s, Brazil decided to build a system of pioneer roads across the Amazon jungle to open up the land. The 5,000 km Trans-Amazonian highway, which runs from north-eastern Brazil westward to Peru, is a major part of this road system. The road was started in 1970 and built by 1974. It is made of hard earth and is not paved, unlike some of the newer roads, such as the Belem-to-Brasilia highway.

The speed of building the road was due to massive international aid and a large amount of technical assistance, such as satellite reconnaissance techniques, heavy earth-moving equipment and helicopters.

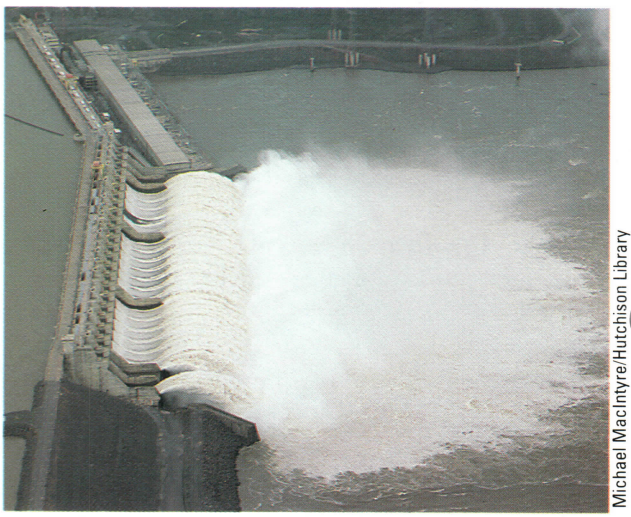
A major project, Project Radam, was also invaluable to the speed of construction. It mapped and surveyed the entire Amazon region from aerial photographs. Detailed aerial maps of the geology, waterways, forestry, vegetation and geography of the Amazon were prepared in less than a year. This would have taken ordinary surveying expeditions 25 years to complete. Aerial surveys can also locate ore deposits by detecting magnetic variations.

REVENGE OF THE JUNGLE

In the 1960s, an American, Daniel K. Ludwig (said at the time to be the richest man in the world), bought a vast area of rain forest in Brazil for about $800 million. He cleared all the native trees and Indians to grow a huge plantation of fast-growing foreign trees, such as eucalyptus and pines. But the trees did not flourish, because the jungle soil did not have enough time to regenerate between the quick plantings. Ludwig abandoned the project in 1982, having lost nearly $75 million.

Tony Morrison/South American Pictures

***A housing** development in the rain forest provides extra accommodation for the overcrowded town of Belem in Brazil.*

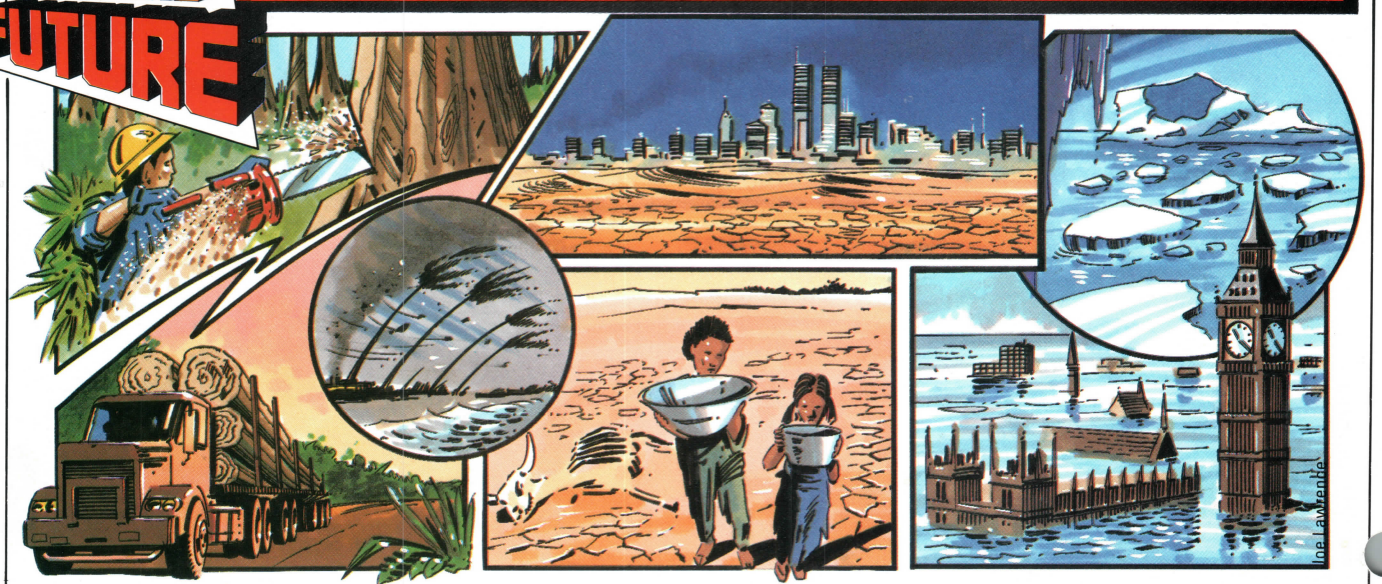


Michael MacIntyre/Hutchison Library

***The Tucurui dam** in Brazil is 2 km long; the reservoir flooded 200,000 hectares of jungle. During construction, four refrigeration plants were built to keep the concrete at the right temperature.*

INTO THE FUTURE

GLOBAL WARMING



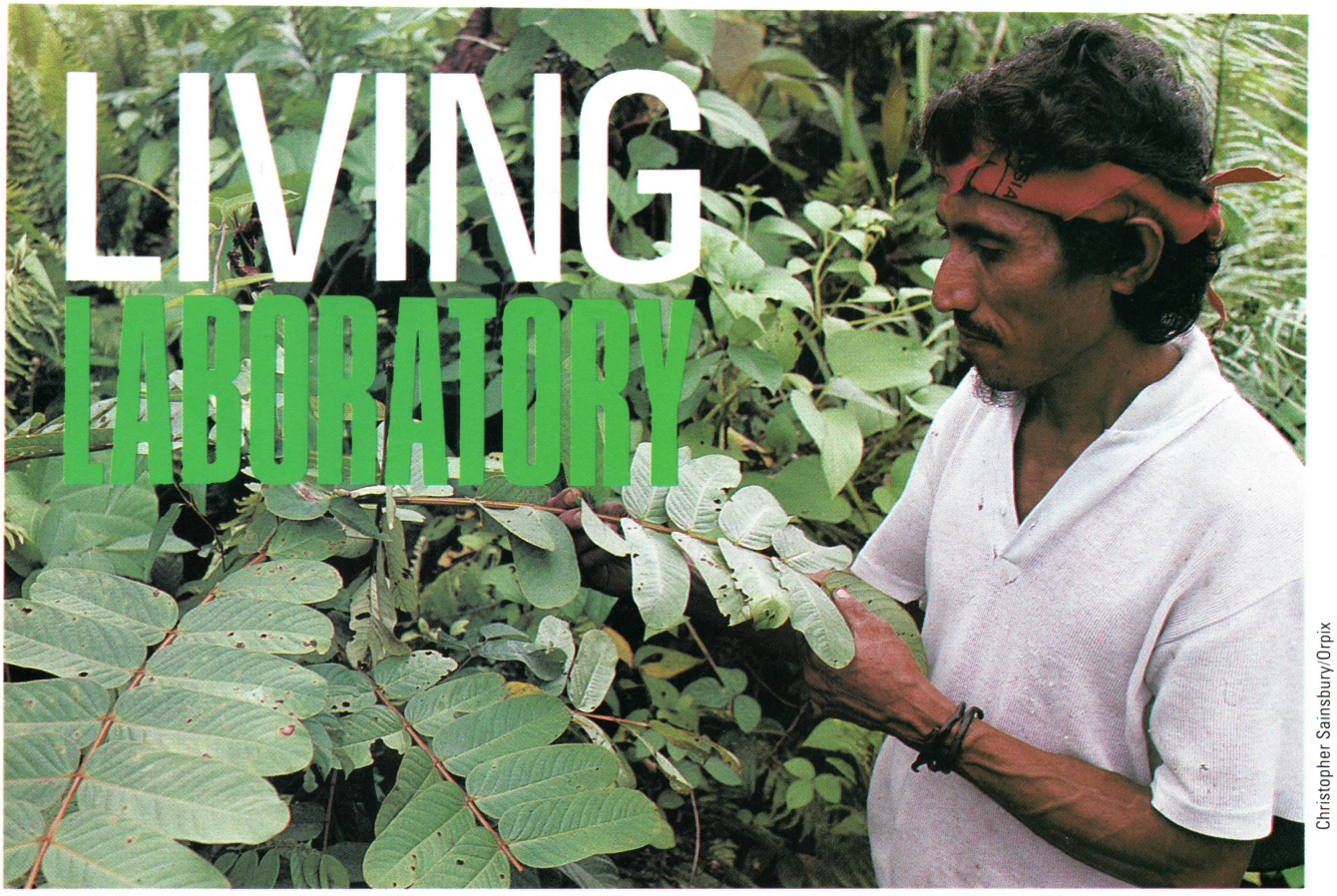
Joe Lawrence

▲ *If the wholesale destruction of the rain forests continues, the shift in the world's weather will cause a global catastrophe because much less rain will fall.*

▲ *Global warming and the resulting drought will turn the major grain-producing areas of the world into deserts. Millions will starve.*

▲ *The polar ice caps will melt, raising the sea level to the point where most of the world's major cities built near the mouths of rivers could be under water.*

LIVING LABORATORY



Christopher Sainsbury/Orpix

***Medicinal plants** are found throughout the jungle. The leaves of this Indonesian shrub are mashed and applied to cuts and wounds to prevent infection.*

SURVIVAL IN THE JUNGLE has been the mother of chemical invention for plants. Over millions of years plants have experimented to produce a range of unpleasant and poisonous chemicals, to deter grazers and pests, and attractive ones to lure pollinators.

About one-third of modern drugs and medicines are made from plant products. Most of the rest were originally made from plants, but are now produced synthetically. Around 400 modern medicines are 'plant drugs'. Manufacturing them represents an industry worth hundreds of millions of pounds yearly – and many of the plants are from the jungle.

One of the basic groups of plant chemicals used in modern medicine is the alkaloids. It includes caffeine (the 'pick-me-up' in coffee), quinine (a cure for malaria) and morphine (a painkiller), all of which affect the brain and nervous system.

Heart failure

Another group is the glycosides, found in foxgloves, cascara and senna; these mainly affect the heart and are used for heart failure and other cardiac problems.

Nearly 2,000 jungle plants have been identified as possible cancer cures. The American mandrake, the bloodroot, one of the crotons and a type of jacaranda are all used by jungle people to treat cancerous growths.

A chemical extracted from the rosy periwinkle – vinblastine, is now used as a treatment for leukemia and helps to keep four out of five children with the disease alive.

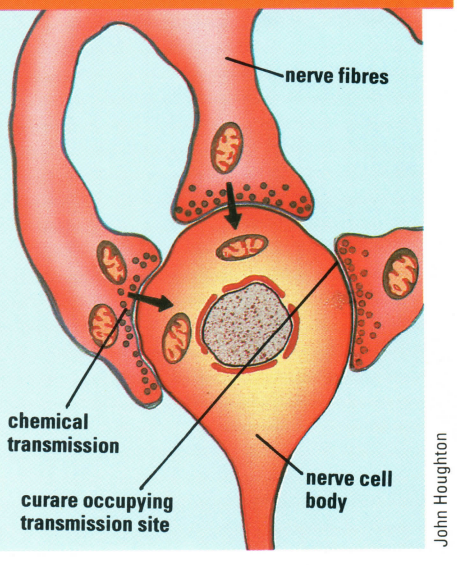
Another rosy periwinkle extract – vincristine – is used to treat the type

William Ransom & Son plc

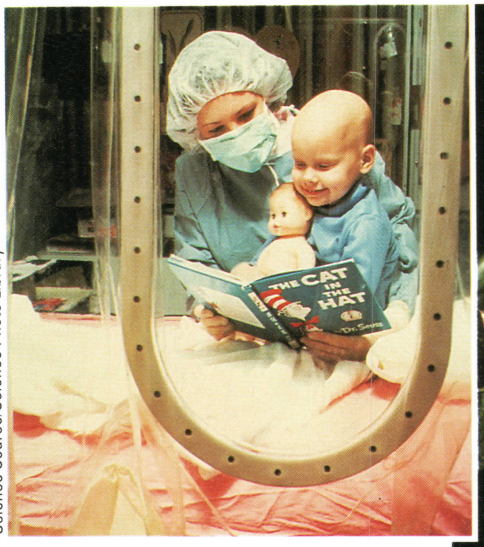
***Concentrated** plant extract collected from the Cocillana bark of the Guarea rusbyi tree, found in the rain forests of Haiti and Bolivia, is used in a cough preparation.*

CURARE – AN OLD DRUG WITH MODERN USES

Curare works by preventing nerve messages from 'jumping' from the end of the nerve to the muscle beyond, so that the muscle is not stimulated to contract. It does this by blocking the action of a chemical messenger called acetylcholine, which would normally cross the microscopic gap between nerve and muscle and slot into receptor sites on the muscle. Curare occupies the receptor sites instead, blocking the chemical messenger without stimulating the muscle.



John Houghton

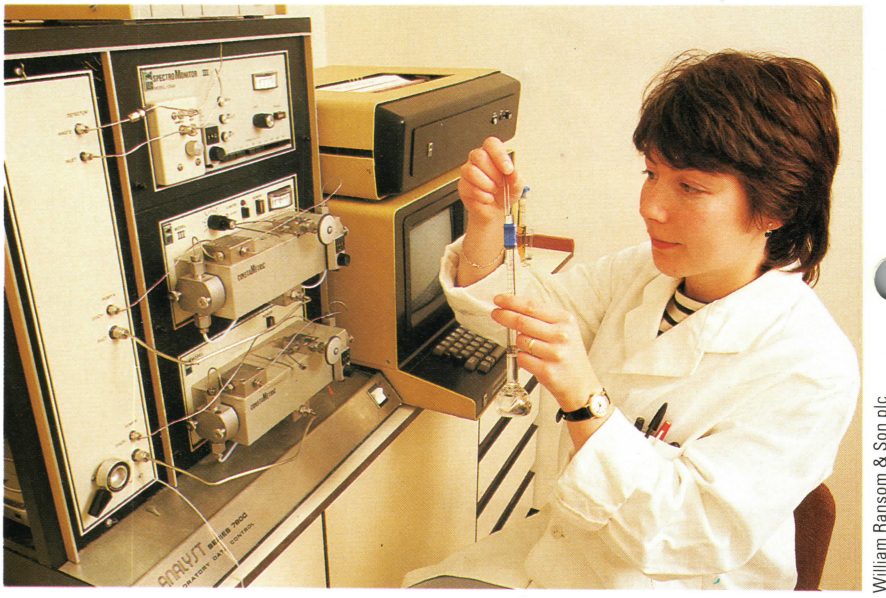


Science Source/Science Photo Library

Neyla Freeman/Bruce Coleman Ltd

The germ-free *chamber (far left) is home to a child suffering from cancer. The drug treatment, known as chemotherapy, that the child is undergoing involves a chemical called vinblastine, an extract of the rosy periwinkle (left).*

Analysis *of medicinal plant extracts can be rapidly achieved in the laboratory using equipment such as this high-pressure liquid chromatograph; this identifies chemicals by the rate at which they move through the liquid.*



William Ransom & Son plc

of cancer known as Hodgkin's disease and four out of five people with this disease recover for months or years. There are, in fact, more than 70 alkaloid substances in this little plant and research is continuing to find the ones that will be useful to medicine.

Curare was used by the jungle people of the Amazon and Orinoco regions to poison the tips of their bamboo arrows. There are several different sorts of curare. One type, tubocurare, is a powerful muscle relaxer and is used in operations, because it enables the surgeon to move around the body's organs more easily. It is also a treatment for conditions such as spastic paralysis, multiple sclerosis and Parkinson's disease.

Quinine revival

Quinine is made from the bark of the chinchona tree, which grows in the jungles of South America and Indonesia. Once the only treatment against malaria, it was gradually replaced by synthetic drugs. Since 1984, however, it has enjoyed a large-scale revival as the microscopic organisms, which cause the disease, have become resistant to many of the synthetic drugs.

In the jungle, plant preparation is quite basic. Depending on where the drug is concentrated, the stem, bark, roots, leaves, flowers or fruits are eaten; or the plant may be crushed and its juice or oil consumed.

One of the oldest methods of extraction is to make a tea by 'infusing' (steeping) the relevant part of the plant in boiling water. Infusion may also be achieved by letting it soak in cold water for several days.

Modern research

In the modern medical laboratory, extraction is by various solvents and chemical reactions. The chemicals can then be separated and identified using chromatography and then 'copied' into a 'purer' form, using laboratory chemical reactions.

Although modern techniques produce a drug with less notable side-effects, some traditional cures only work 'straight from the plant'. This is because their ability to cure comes from the various chemicals in the plant working together, not from the action of one chemical on its own.

Medicinal plants

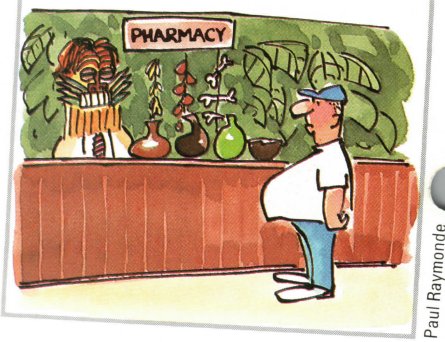
There are literally thousands of jungle plants with medicinal uses. The snakeroot plant from Indian forests, for example, has been taken to help overcome insomnia and is also used as a sedative.

Ipecacuanha, a Brazilian jungle shrub, contains a drug that causes vomiting – useful in cases of poisoning. Modern man has, however, largely left such medicinal secrets to the native peoples.

Just amazing!

NATURAL DRUGS

MORE THAN 40 PER CENT OF ALL THE DRUGS PRESCRIBED TO PEOPLE IN THE USA ARE BASED ON CHEMICALS DERIVED FROM RAIN FOREST PLANTS.



Paul Raymonde

BIOTECHNOLOGY

FARMERS HAVE CROSS-BRED their crops to try and increase yields and eradicate disease throughout history. Such trial and error methods, however, take years and the results are always uncertain. Plant clones, on the other hand, are identical to the parent and may be reproduced endlessly.

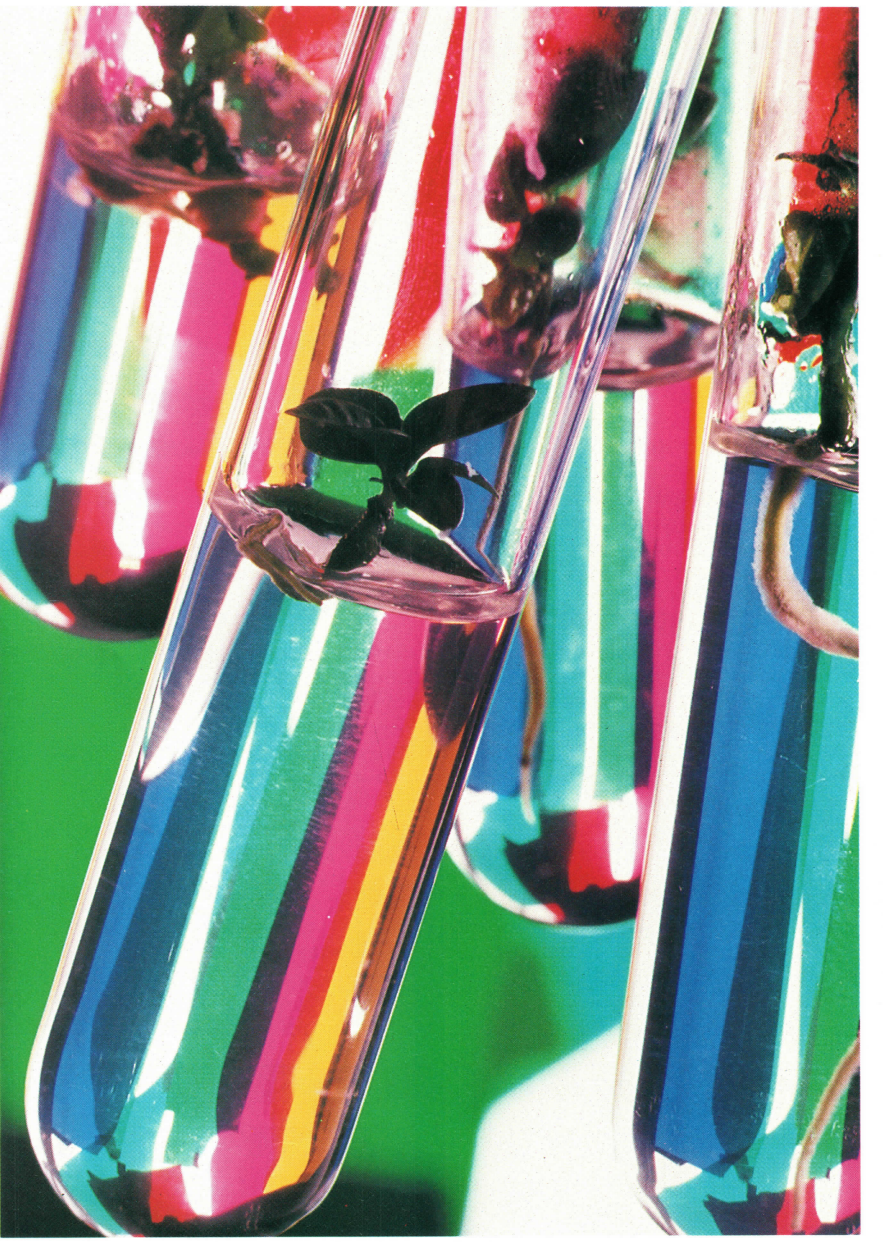
Simply by taking a leaf or shoot cutting from a plant and nurturing a new plant from it, you are reproducing a single plant that is genetically identical to its parent. Although effective, this method is not very efficient for large-scale reproduction.

One alternative, used in the mass propagation of the jojoba plant, is the shoot tip method. Tiny shoots are cut from the parent plant and grown in a sterile jelly rich in nutrients. Once stimulated to bud in this way, the little plants are rooted.

Forming a callus

In some cases, however, the normal methods of tissue culture do not work. Thus, to clone the oil palm, for example, it is necessary to produce an intermediate clump of cells called a callus. Root tissue from the desired plant is placed in a nutrient-rich jelly and stimulated by growth hormones to form the disorganized mass of cells known as a callus. Once formed, a callus can be subdivided in the laboratory almost indefinitely and nurtured to produce large numbers of embryo plants, or clones, each genetically identical to the parent plant.

Cloning is very important in farming and forestry where the best plants can be reproduced as required. Trees take years to grow, but only minutes to cut down. In the laboratory, however, hundreds of seedlings can be produced very quickly. Furthermore, the trees grown from them will have the appropriately desired qualities such as height, straightness and fewest branches. Plantations 'con-

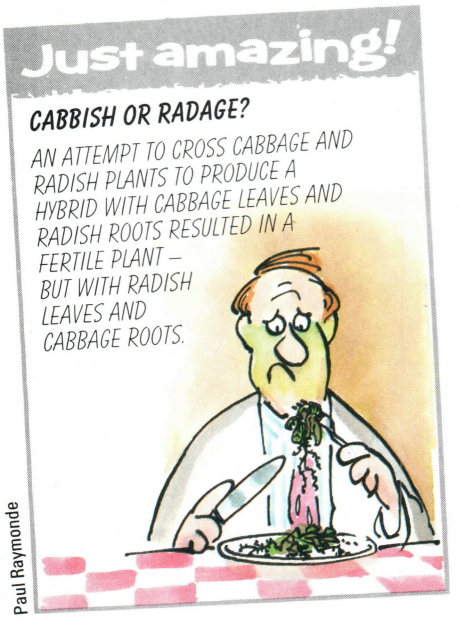


Charlotte Raymond/SPL

Seedlings, *developed from tissue cultures, growing in a sterile growth medium in test tubes. This technique enables rapid and prolific propagation and is used to make crops that are resistant to virus infection and disease.*

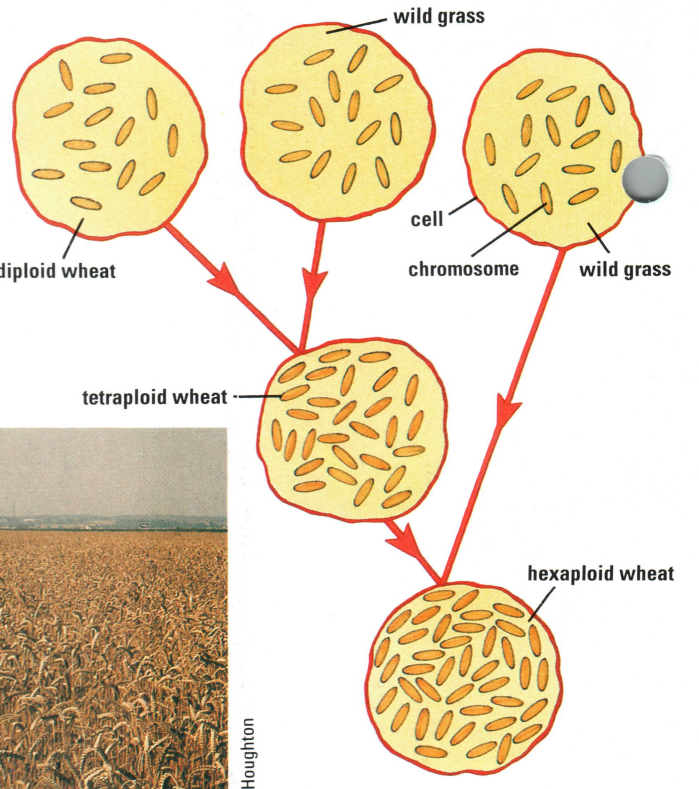
USDA/ARS

Selective breeding *programmes are aimed at making plants resistant to insects like the potato beetle.*



Paul Raymonde

Cross-breeding *has created hardier types of wheat that are far easier to harvest (below). The ability of many plants to double or treble the number of their chromosomes is known as polyploidy. Crossing a primitive, diploid, wheat with a wild grass produces an improved, tetraploid, type. Crossing this again produces even better, hexaploid, wheat.*



ZEFA

John Houghton

structed' from cloned plants typically give a 20–30 per cent better performance than comparable uncloned plantations.

Cloning methods have also been put to good use for the production of certain drugs. Instead of allowing plant tissue to develop into plants, cells from the Madagascar periwinkle, for example, can be maintained in flasks where they produce vincristine – a chemical that is used in the treatment of leukaemia.

Manipulating genes

Beyond cloning is the area of genetic engineering. Scientists are able to introduce specific new characteristics into plants by manipulating the appropriate gene or genes into the plant's chromosomes while they are being cultured.

First, the new gene is isolated from the DNA (deoxyribonucleic acid) of the donor species and introduced into the parent plant cells, which are then grown into adult plants. The manipulated plants are known as 'transgenic' plants. Such techniques have successfully produced fields of rye that are resistant to damage by certain toxic chemicals, and tobacco plants that are resistant to insect pests, virus and disease.

In spite of Man's success as creator of new, improved plants, nature has in fact been experimenting genetically for a lot longer. An unusual trait of plant reproduction is the ability of many plants to double or even treble the number of chromosomes without adverse effect. Having multiple sets of chromosomes is known as polyploidy and is achieved either by the plant hybridizing with itself or, less commonly, with another plant species, with all the chromosomes being retained.

When polyploidy occurs in Man or other animals the foetus usually dies because increasing the number of chromosomes in the cell makes cell division impossible.

In plants, on the other hand, polyploidy occurs naturally. Around 40 per cent of all plants are either polyploid or of polyploid origin. The offspring are thus genetically isolated from the parent species.

Sinclair Stammers/SPL

Anti-cancer drugs, *vinblastine and vincristine, are produced from tissue culture of the Madagascar Periwinkle.*

Fusion hybrid is the name given to new plants, normally close relatives such as cabbage and Chinese cabbage, which are created artificially. In this technique cells are isolated and 'protoplasts' – a kind of cellular stew – made from them by removing the cell walls. The protoplasts from two species are then fused in an attempt to create a hybrid with the best characteristics from each parent.

THE FOREST SAVER

Kenaf is a plant that is currently being grown in the USA for its potential as high quality newsprint. Since the 1940s kenaf has been selectively bred to produce a higher ratio of the usable outer bark. In the 60s and 70s more work has gone into producing a plant that is tolerant of a crippling organism, root knot nematode, that is found in the light, sandy soils of the southern USA. Such varieties are now being successfully farmed. One project in Texas involves planting kenof on 40,000 acres for a papermill which can produce 225,000 tonnes of newsprint a year. The paper is brighter than paper made from wood pulp. It does not yellow as quickly and retains ink far better.

USDA/ARS

GENETIC ENGINEERING

- MAKING INSULIN
- TRANSGENIC ANIMALS
- A HUMAN GENE MAP

THE UNDERSTANDING OF DNA has opened up a whole new branch of technology called genetic engineering. Like much of modern science, it offers a choice between dream and nightmare, depending on how the techniques are used.

Every gene works by acting as the template or pattern for the formation of a protein. A lot of foods and drugs as well as many industrial products are made of protein, so the discovery of DNA presented the possibility of using genetic material for manufacturing purposes.

A drug called human insulin was one of the first substances that anybody thought of making through genetic engineering. The first step was to locate the human gene responsible for insulin production and then find a way that it could produce insulin away from the human body. The easiest route was to fit the gene in a simple bacteria found in the human stomach called *Escherichia coli*.

This organism was chosen because it contains separate rings of DNA (called plasmids) that can easily be removed from the cell. The DNA rings are snipped open and the human insulin gene 'glued' into the ring using enzymes. When the modified DNA ring is replaced in the *E. coli* bacterium, it produces insulin using the information carried in the insulin gene.

To encourage *E. coli* to reproduce as fast as possible, the modified bacteria are placed in a bioreactor. This is a large container of warm water containing plenty of nutrients, with air bubbling through it so that *E. coli* can breathe.

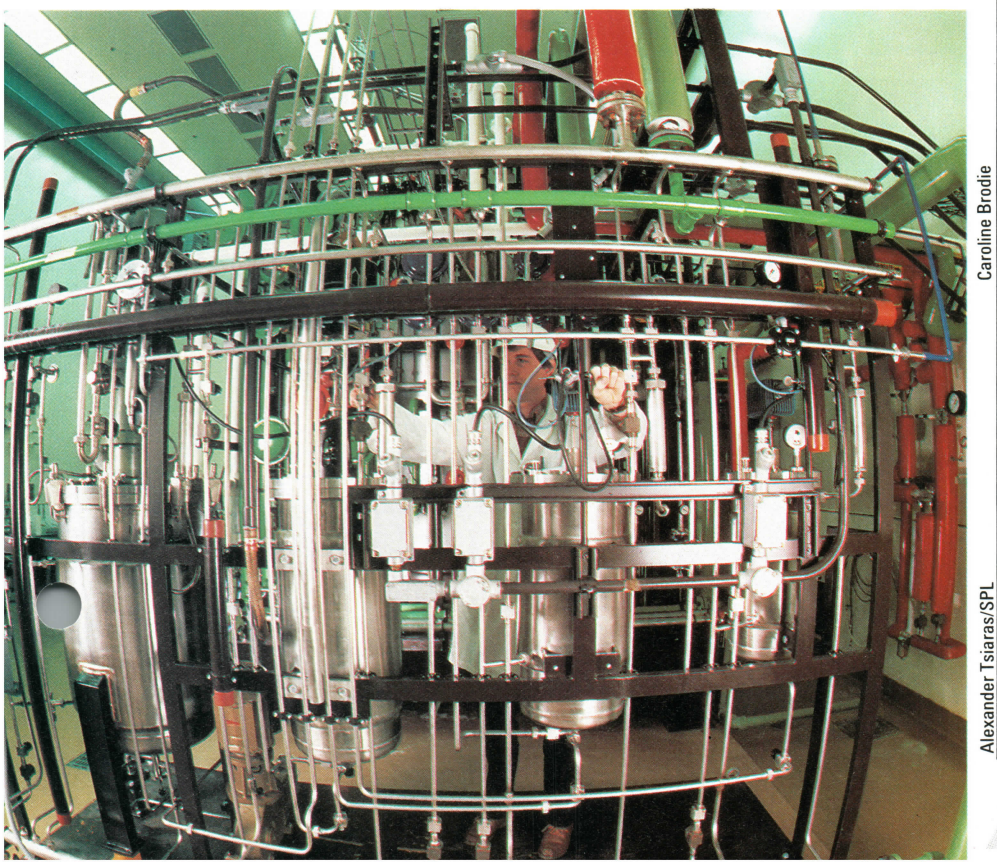
New drug source

Several other drugs like Human Growth Factor and an agricultural hormone called BST are already being made using similar types of genetically-engineered bacteria. The splitting apart of the ring of DNA, to be recombined with a piece of DNA from another organism is known as recombinant DNA technology. In the future, this will almost certainly become a source of many more drugs.

Bacteria can be modified to digest things like grass or even oil which cannot be digested by humans. The protein will be extracted, shaped and flavoured so that it resembles meat.

Scientists can also transfer genes from one animal species to another. The desired gene is first separated from the rest of the chromosomes and cloned in exactly the way described above for insulin. DNA can be obtained from any tissue or cell

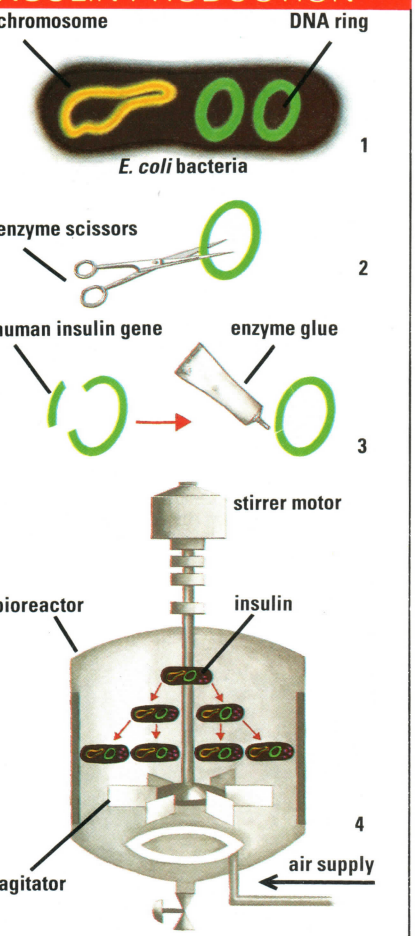
***Large quantities** of genetically engineered bacteria are encouraged to reproduce in fermentation units.*



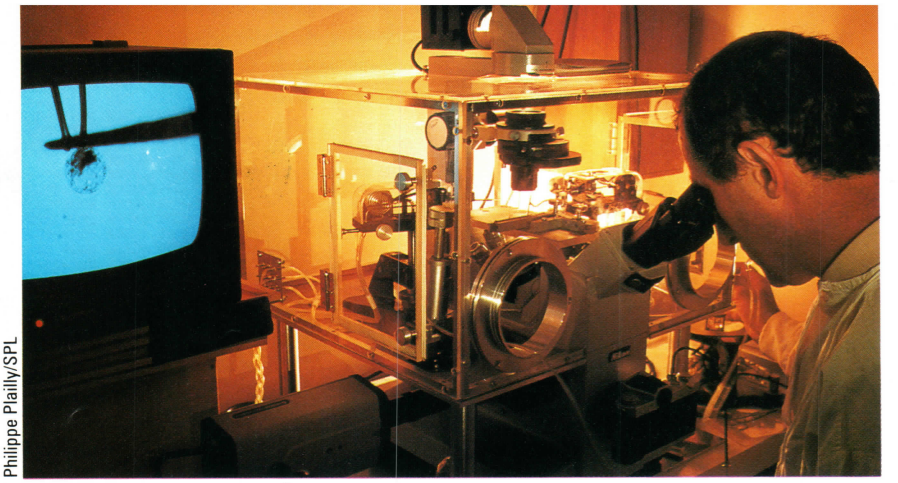
Alexander Tsiaras/SPL

Caroline Brodie

INSULIN PRODUCTION



A bacterium from the human intestine called *E. coli* (1) is the workhorse of genetic engineering because it contains separate rings of DNA which are easy to remove. To make human insulin, the DNA rings are opened up (2) and the gene for making human insulin is fitted into the ring using a chemical – an enzyme – called ligase (3). The modified DNA ring is then replaced in the cell of *E. coli* and fed into a bioreactor (4). Each cell produces some insulin and when the bioreactor is full, the bacteria are broken open chemically and the insulin is extracted. Insulin regulates the amount of sugar in the blood. Without it, diabetics die.



Philippe Plailly/SPL

***TV cameras** take the image from a microscope and feed it onto a screen, allowing genes to be microinjected.*

type for this purpose (often white blood cells are used). Copies of the DNA are produced in bacterial cultures, the desired gene is purified and then 'micro injected' into the nucleus of an egg of the other species using a special syringe.

Animals that develop from these eggs with microinjected genes are known as transgenic animals. The first such animals were mice bred for use in laboratory experiments. These mice were given the growth hormone gene of a rat and some of them grew to twice normal size!

Recently, a human gene responsible for the production of a part of human blood known as Factor IX has been transferred into some sheep eggs. Factor IX is the part of human blood which makes it clot after a cut. Somebody who does not produce this part of blood for themselves can easily bleed to death, so they must receive Factor IX regularly.

The transgenic sheep have the Factor IX gene in every cell and produce large quantities of Factor IX in their milk. This is very convenient because it means that the Factor IX can be extracted from the milk.

One of the most promising areas of cancer research at the moment is to take some of the natural antibodies from the patient's bloodstream and grow large quantities of them in the laboratory. These are injected back into the patient in the hope that the extra antibodies will beat the cancer.

To help them study this process, the researchers are using a bacteria to mark the nucleus of the antibody cells.

Human genes

In America, the largest genetic engineering programme of all time has already begun. The aim of the programme is to produce a map of all 80,000 or so human genes.

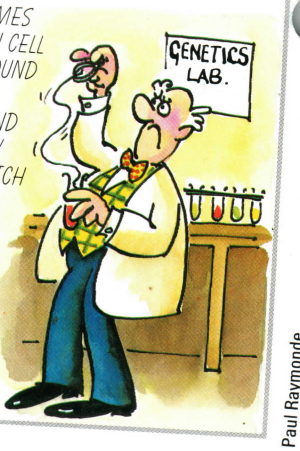
Such a map is known as the human genome and this project will cost more than putting a man on the moon. But many scientists are worried about this sort of research. It could help scientists to study and cure genetic diseases but the same knowledge could also be used to engineer different breeds of humans. For example somebody could decide to create a 'genetic soldier'. He would be small and very powerful but pitiless and 'programmed' to obey orders without fear or doubt.

At the moment, few countries have laws against this type of research. However, the European Research Council have advised genetic researchers that introducing 'alien' genes into the egg and sperm cells of human beings is quite unacceptable. If this is permitted to ever happen, it would permanently alter the pool of human genes.

Just amazing!

CHAIN OF COMMAND

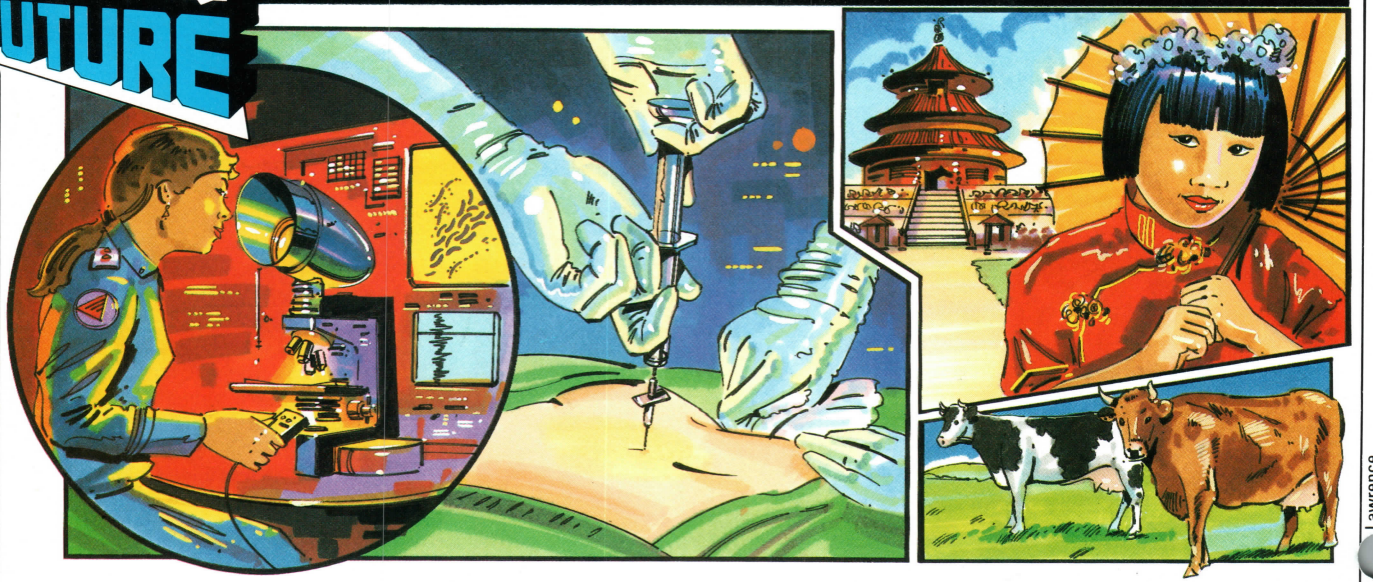
IF ALL THE 46 TIGHTLY COILED CHROMOSOMES IN A HUMAN CELL WERE UNWOUND AND PUT TOGETHER END TO END, THEY WOULD STRETCH TO 1 METRE.



Paul Raymonde

INTO THE FUTURE

GENE GENIUS – A THREAT OR A PROMISE



Lawrence

▲ *The human body has no defence against genetically-engineered viruses, so there will be a well-trained genetic police force to control laboratories and hospitals.*

▲ *Leukaemia caused by genetically-defective bone marrow could be cured by extracting the bone marrow, adding the normal gene, then replacing it.*

▲ *Lactose is a component of milk that cannot be digested by many people in the Far East. A gene will be modified to produce lactose-free milk.*

SPLITTING SECONDS

- TIMEKEEPING
- ATOMIC CLOCKS
- THE WORLD'S TIME

Star trails *over the Himalayas, captured by time exposure photography.*

Spectrum Colour Library

THE EARTH WAS MANKIND'S first clock. The time our planet takes to rotate once on its axis – approximately 24 hours – gives us the length of the day. The time it takes to travel around the Sun gives us the year.

But the Earth is a poor timekeeper by modern scientific standards. We now take our time from the vibrations of atoms in super-precise atomic clocks.

The time of day

A few hundred million years ago there were 400 days in the year. Since the time that the Earth takes to orbit the Sun does not change, this means that the day was then about 22 hours long. One piece of evidence for this comes from fossil corals that show patterns of daily and yearly growth. There is a steady long-term slowing of the Earth's rotation, caused by the drag of the tides. As a result, the day is getting longer – apparently by about 1½ milliseconds per century.

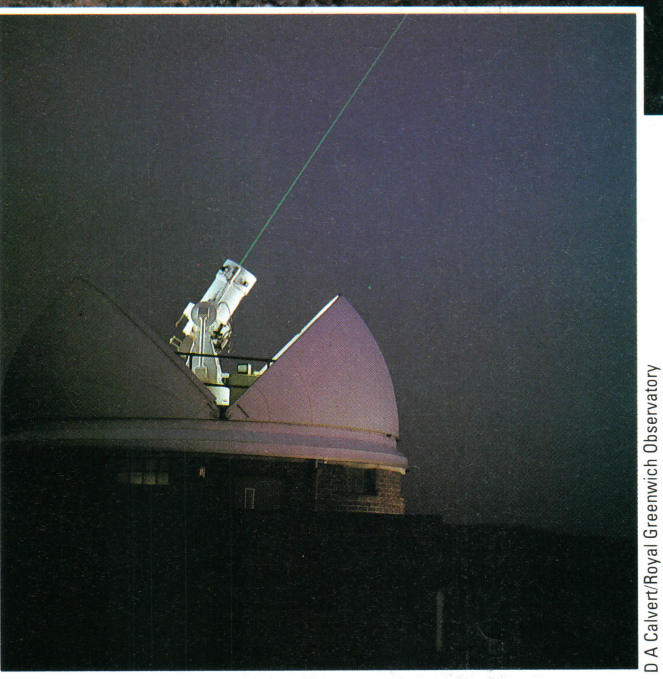
In the short term, the Earth's rotation rate slows down and speeds up by as much as one millisecond (one thousandth of a second) from day to day. These changes are random and unpredictable, caused by such factors as movements in the Earth core and changes in the circulation of the atmosphere.

The measurement of time by clocks has improved dramatically in the 20th century. Until the 1930s the most accurate clocks used pendulum – a weight swinging on the end of a cord or rod. The best pendulum clocks can measure time to an accuracy of a millisecond per day.

The pendulum clock was superseded by the quartz crystal clock, in which a vibrating quartz crystal is used to regulate the rate of thousands of electrical pulses produced every second by an electronic circuit called an oscillator. Another circuit counts the number of pulses required to make a certain fraction of a second, and then sends a single pulse to update the clock's digital display by this amount.

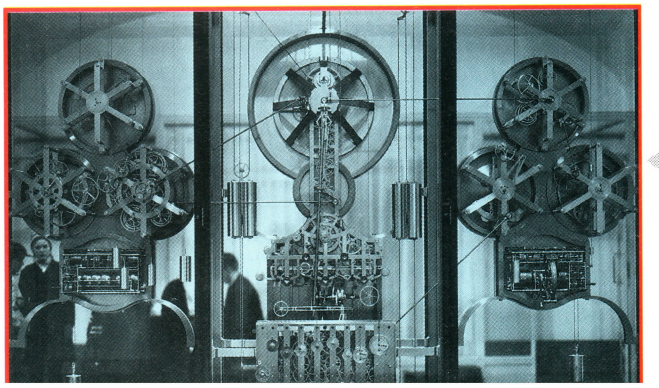
The complicated electronic circuits needed to count the electrical pulses have been squeezed into microchips, and many wristwatches now use quartz crystals. The best

Earth Rotation *time is measured by the Satellite Laser Ranger at the Royal Greenwich Observatory in Sussex, England, as part of a programme involving 30 stations around the world. The distances to special satellites in stable orbits, as measured by the reflected laser pulses, vary if the Earth's rate of rotation changes.*



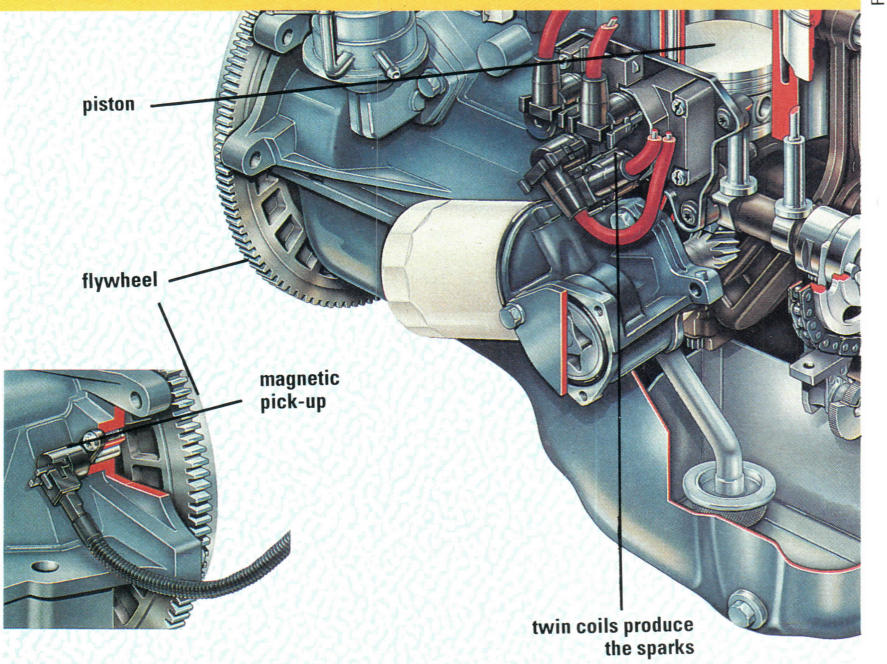
D A Calvert/Royal Greenwich Observatory

AUE/The Danish Tourist Board



The Olsen Clock *has the most accurate and complicated clockwork in the world. Built in Copenhagen Town Hall, it is made up of more than 14,000 parts.*

TIMING THE SPARKS



Ford

In petrol engines, the ignition system has to deliver a spark up to 6,000 times every minute – each spark timed precisely to coincide with the moment that one of the pistons in the engine comes to the top of its stroke. A mechanical distributor is normally used to do this job. But like all mechanical devices it is subject to wear and tear.

Some modern cars do away with the distributor – and its disadvantages. Instead a magnetic pick-up creates a signal that changes as the engine runs faster. This signal, plus information on engine temperature and throttle opening, is fed into an electronic processor, which triggers the spark at exactly the right moment in each cylinder.

About 80 per cent of breakdowns are caused by ignition and distributor problems, most of which will be eliminated by electronic systems.

quartz clocks, used in scientific laboratories can keep time to within one ten thousandth of a second in a day.

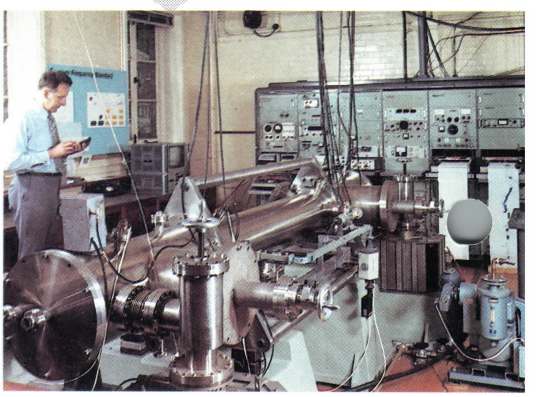
The most accurate timekeepers of all are atomic clocks, which are large, complex, scientific instruments. The caesium-beam clock is so accurate that the second is now defined as the time occupied by 9,192,631,700 cycles of the particular microwave radiation produced by it.

An atomic clock can control the transmission of a radio signal that can be picked up by a clock on the mantelpiece of an ordinary house. The battery powered clock automatically tunes in to the signal and checks its time against the atomic clock at regular intervals.

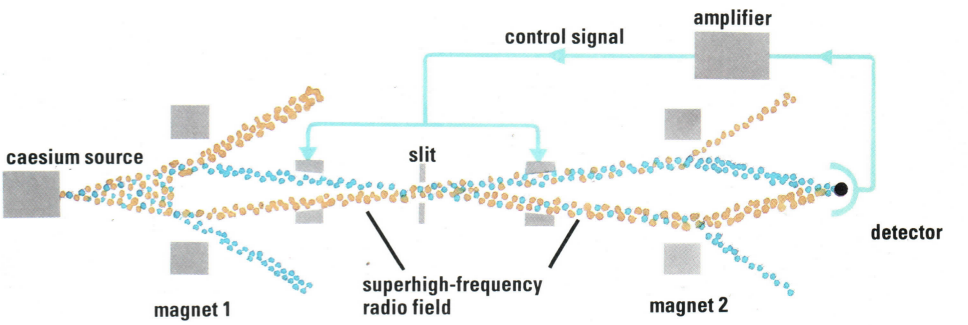
Today there are various ways of measuring the World's time:

- **Earth Rotation Time** is based on the exact time the Earth takes to rotate once, as calculated at the International Time Bureau in Paris from worldwide observations.
- **International Atomic Time** is time as defined by very precise atomic clocks at centres around the world, such as the National Physical Laboratory, Teddington, Middlesex, in southern England.
- **Coordinated Universal Time** is also known as Greenwich Mean Time. It is an internationally agreed atomic time that is occasionally adjusted by the addition or subtraction of one 'leap second' (at the end of the day on 30 June or 31 December) so as to keep in step with Earth Rotation Time, which is the time we live by. When this happens there are either five pips or seven pips in the time signal transmitted by the BBC (British Broadcasting Corporation) instead of the usual six pips.

***The 'NPL second'**, is measured by the caesium atomic clock at the National Physical Laboratory near London.*



Crown copyright/National Physical Laboratory



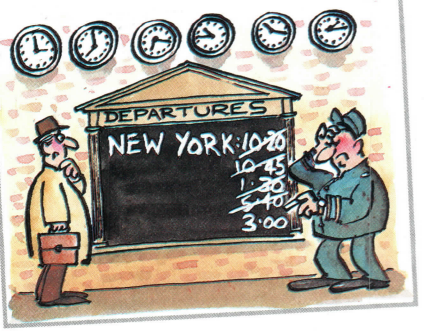
Janos Marffy

***An atomic clock** uses a beam of atoms of the metal caesium. Each atom is like a tiny magnet pointing in a certain direction. Atoms pointing in the right direction are focused by magnet 1 so that they pass through a slit. Superhigh-frequency radio waves 'flip' the caesium atoms' directions, and magnet 2 focuses the flipped atoms on to a detector. The maximum number of atoms reach the detector when the radio frequency is exactly right. The vibrations of the radio waves are counted and displayed as the time.*

Just amazing!

THE TRAIN NOW DEPARTING . . .

IN PITTSBURGH'S MAIN STATION YOU COULD ONCE SEE CLOCKS SHOWING SIX DIFFERENT TIMES. EACH RAILWAY COMPANY IN THE USA KEPT TO THE LOCAL TIME OF ITS OWN HEAD OFFICE.



Paul Raymonde